BEHAVIORAL AND BRAIN SCIENCES (2005) **28,** 675–735
Printed in the United States of America

Understanding and sharing intentions: The origins of cultural cognition

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Abstract: We propose that the crucial difference between human cognition and that of other species is the ability to participate with others in collaborative activities with shared goals and intentions: shared intentionality. Participation in such activities requires not only especially powerful forms of intention reading and cultural learning, but also a unique motivation to share psychological states with others and unique forms of cognitive representation for doing so. The result of participating in these activities is species-unique forms of cultural cognition and evolution, enabling everything from the creation and use of linguistic symbols to the construction of social norms and individual beliefs to the establishment of social institutions. In support of this proposal we argue and present evidence that great apes (and some children with autism) understand the basics of intentional action, but they still do not participate in activities involving joint intentions and attention (shared intentionality). Human children's skills of shared intentionality develop gradually during the first 14 months of life as two ontogenetic pathways intertwine: (1) the general ape line of understanding others as animate, goal-directed, and intentional agents; and (2) a species-unique motivation to share emotions, experience, and activities with other persons. The developmental outcome is children's ability to construct dialogic cognitive representations, which enable them to participate in earnest in the collectivity that is human cognition.

Keywords: collaboration; cooperation; cultural learning; culture; evolutionary psychology; intentions; shared intentionality; social cognition; social learning; theory of mind; joint attention

Human beings are the world's experts at mind reading. As compared with other species, humans are much more skillful at discerning what others are perceiving, intending, desiring, knowing, and believing. Although the pinnacle of mind reading is understanding beliefs – as beliefs are indisputably mental and normative – the foundational skill is understanding intentions. Understanding intentions is foundational because it provides the interpretive matrix for deciding precisely what it is that someone is doing in the first place. Thus, the exact same physical movement may be seen as giving an object, sharing it, loaning it, moving it, getting rid of it, returning it, trading it, selling it, and on and on – depending on the goals and intentions of the actor. And whereas understanding beliefs does not emerge until around age 4 in human ontogeny, understanding intentions begins to emerge at around a child's first birthday.

Human beings are also the world's experts at culture. Humans do not just interact with conspecifics socially, as do many animal species, but they also engage with them in complex collaborative activities such as making a tool together, preparing a meal together, building a shelter together, playing a cooperative game, collaborating scientifically, and on and on. These collective activities and practices are often structured by shared symbolic artifacts, such as linguistic symbols and social institutions, facilitating their "transmission" across generations in ways that ratchet them up in complexity over historical time. Children become more skillful at collaborating and interacting with others culturally throughout early childhood, but their first nascent attempts begin, once again, at around the first birthday.

Tomasello et al. (1993) argued and presented evidence that these two dimensions of human expertise – reading intentions and interacting with others culturally – are intimately related. Specifically, the way humans understand the intentional actions and perceptions of others creates species-unique forms of cultural learning and engagement, which then lead to species-unique processes of cultural cognition and evolution. For example, it is only if a young child understands other persons as intentional agents that she can acquire and use linguistic symbols – because the learning and use of symbols requires an understanding that the partner can voluntarily direct actions and attention to outside entities. Indeed, material and symbolic artifacts of all kinds, including even complex social institutions, are in an important sense intentionally constituted (Bloom 1996; Searle 1995; Tomasello 1999a).

Recently, however, some new empirical findings have emerged which suggest that understanding intentions cannot be the whole story of cultural cognition. Briefly, the main finding is that some nonhuman primates understand more about intentional action and perceptions than was previously believed (and this is also true, to some degree, of

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children with autism). But they do not thereby engage socially and culturally with others in the ways that human children do. Therefore, understanding the intentional actions and perceptions of others is not by itself sufficient to produce humanlike social and cultural activities. Something additional is required.

Our hypothesis for this "something additional" is shared intentionality. We propose that human beings, and only human beings, are biologically adapted for participating in collaborative activities involving shared goals and socially coordinated action plans (joint intentions). Interactions of this type require not only an understanding of the goals, intentions, and perceptions of other persons, but also, in addition, a motivation to share these things in interaction with others – and perhaps special forms of dialogic cognitive representation for doing so. The motivations and skills for participating in this kind of "we" intentionality are woven into the earliest stages of human ontogeny and underlie young children's developing ability to participate in the collectivity that is human cognition.

In this article, we explicate and elaborate this account of how humans come to (1) understand intentional action and (2) participate in activities involving shared intentionality. Our focus is on how these two skills interweave during normal human ontogeny, but we also review recent empirical findings with great apes and children with autism, providing the skeleton of an evolutionary account in the process. We employ a "control systems" approach (from cybernetic theory) to characterize the structure of intentional action and a "shared intentionality" approach (from the philosophy of action) to characterize the types of cognitive skills and social engagements that make possible uniquely human activities such as the creation and use of linguistic and mathematical symbols, the creation and use of artifacts and technologies that accumulate modifications over generations in cultural evolution, and the creation of social practices and institutions such as marriage and government that depend on collective beliefs – in short, what we will call *skills of cultural cognition*.

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1. Intentional action

If we want to know how people understand intentional action, we must first have a model of exactly what intentional action is. Here we propose a simple model based on control-systems principles – in which goal, action, and perceptual monitoring are all seen as components in the larger adaptive system that serves to regulate the organism's behavioral interactions with the environment.

As discovered by cyberneticians such as Weiner (1948) and Ashby (1956), machines that act on their own "intelligently" all have the same basic organization involving the same three components: (1) a reference value or *goal* toward which the system acts, (2) the ability to act in order to change the environment, and (3) the ability to perceive the environment so as to know when the state of the environment matches the reference value. The prototypical exemplar, of course, is the thermostat which – all by itself without human intervention – can regulate the temperature of a room. It does this by (1) having a reference value set by a human (e.g., 25 degrees), (2) being able to turn on or off an air heater or cooler, and (3) being able to sense the room temperature (e.g., with a thermometer) and compare it to the reference value to determine whether heating, cooling, or no action is required. This circular organization – goal determines action, which changes perception (feedback), which (when compared to goal) again determines action – makes the thermostat a self-regulating device.

The application of this insight to human intentional action is depicted in Figure 1, using the example of an individual faced with a closed box and wanting it open. This diagram embodies a number of the terminological conventions we will use in our review of the empirical literature, as well as some substantive points about how we think intentional action works. To begin at the top of the figure, the word *goal* contains a systematic ambiguity that has contributed to much confusion (e.g., see Want & Harris 2001). When it is said that a person wants a box open, for example, we may distinguish the external goal – a certain state of the environment such as an open box – and the internal goal – an internal entity that guides the person's behavior (e.g., a mental representation of a desired state such as an open box). We will reserve the term goal for the internal goal, and for the external goal we will use such expressions as "the desired result".

Another important distinction that is not always clearly made is that between goal and intention. Following Bratman (1989), we propose that an intention is a plan of action the organism chooses and commits itself to in pursuit of a goal. An intention thus includes both a means (action plan) as well as a goal (in Fig. 1, the intention includes both the goal of an open box as well as the action plan chosen to make that happen). The fact that the intention includes the goal

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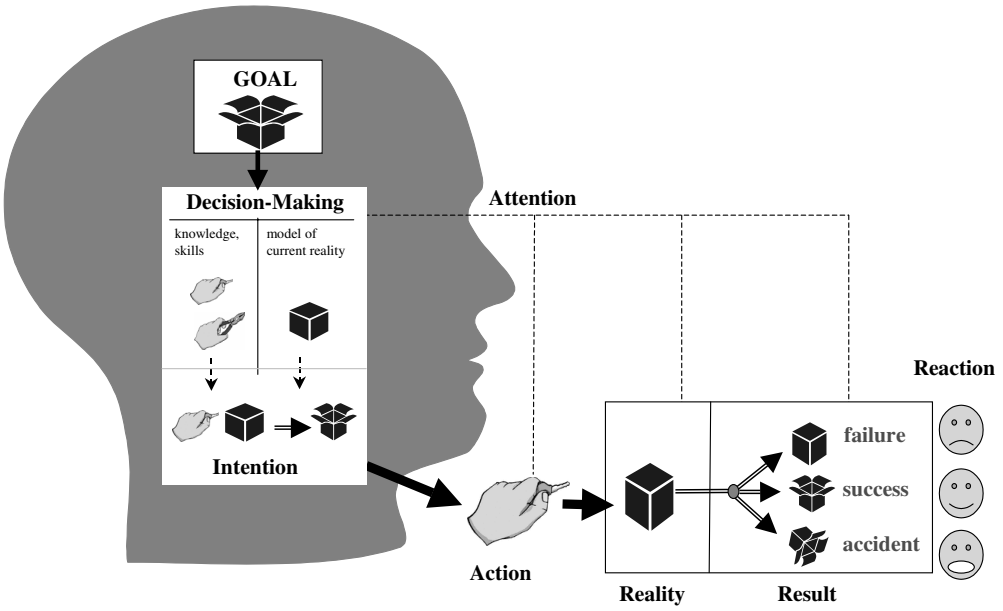

Figure 1. Human intentional action. The goal is an open box; reality is a closed box. The actor chooses a means (plan), depicted as hands doing things, which forms an intention. The resulting action causes a result, which leads to a reaction from the actor.

explains why the exact same action may be considered different things intentionally; for example, cutting the box as an act may be either "opening it" or "making kindling," depending on the goal. So the organism has the goal "that X be the case" and the intention "to do A" in pursuit of that goal. In choosing an intended course of action (*decision making* in Fig. 1), the organism consults both its stored knowledge/skills and its mental model of current reality – that is, those aspects that are "relevant" to the goal. The chosen action is "rational" to the degree that it effectively accommodates the organism's knowledge, skills, and model of current reality.

Moving out of the organism and into the realm of what is observable from outside, the organism's intention typically results in concrete behavioral action of one sort or another (*large hand* in Fig. 1). This is often accompanied by such things as signs of effort and direction of gaze. Also relevant is current reality – a *closed box* in Figure 1 – and any additional constraints in the context (e.g., a lock on the box). After the action on reality has taken place, the state of the world is transformed in one way or another (including no change), and we call this the result of the action, which is also typically observable. In Figure 1, we can see various ways that the result may or may not match the goal: (1) a failed attempt, in which the action does not succeed in changing the state of reality to meet the goal; (2) success in which the action changes reality so as to match the goal; and (3) an accident, which is also not successful but for different reasons (the action causes an unintended result). Quite often, each of these results is accompanied by an emotional reaction on the part of the behaving organism: disappointment at failure, happiness at success, and surprise at an accident (also depicted in Fig. 1). The two types of results representing failure are typically followed by persistent, often variable, efforts toward the goal.

Finally, crucial to the whole process is the organism's perceptual monitoring throughout (the *dashed lines* in Fig. 1). The organism monitors the situation to see (1) what is the current reality (information it uses continuously), (2) whether it executed the action intended, and (3) the result produced by the action. In Figure 1, the label used is not perception but attention. The reason is that in each of these cases the organism is not perceiving everything, but rather it is attending to just those aspects of the situation that are relevant to the goal at hand. Thus, the organism may not pay attention to the color of the box, the temperature of the room, or other things unrelated to its goal. As we have argued previously (e.g., see Tomasello 1995), attention may thus be thought of as intentional perception (selective attention). This monitoring process thus completes the circular arrangement characteristic of intentional action: the organism acts so as to bring reality (as it perceives it) into line with its goals.[1]

Two complications. First, it is important to recognize the hierarchical structure involved here (Powers 1973). Once the organism chooses an action plan to enact in intentional action, it typically must also create lower-level goals and action plans. For example, in Figure 1 the plan chosen for achieving the goal of an open box might involve opening it with a key. This requires having an appropriate key in hand (as subgoal), which means creating a subplan to walk to the nearby drawer, open it, fetch the key, return to the box, and use the key. At each step of choosing a subgoal and subplan, there are potentially multiple possibilities to choose from, and these must be assessed with respect to their predicted efficacy – what we will call *decision making*. And we must not forget the higher-level goals either. The organism wants the box open for a reason; perhaps it has a higher-level goal of obtaining the birthday gift sent by Uncle Ralph, and therefore opening the box is, from this higher perspective, only a means. In general, what is a goal when viewed from beneath is a means when viewed from above. Starting at any given level, moving up to more general goals explains *why* a person has a particular goal: she wants the box open in or-

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der to obtain the gift. Moving down the hierarchy to more specific action plans specifies *how* a goal is achieved in terms of intentional actions: she intends to open the box by using a key.

Second, a related complication is that an organism may have as a goal some movement or action in itself; for example, a dancer's goal is simply to perform certain body movements that have no observable environmental effects. And it may also happen that an object-related goal includes as a component a specific action. Thus, as a child approaches the box, we might think either that her goal is that it be open (and the means chosen to do it is cutting with scissors) or, alternatively, that her goal is that she open it by cutting with her new scissors. The distinguishing test is easy. If we open the box before the child arrives, in the first case she will be happy (she only wanted it open), whereas in the second case she will be unhappy (she wanted to do it herself by cutting with her new scissors). This complication – that organisms may have as goals either environmental effects or self-actions or some combination of both – plays a crucial role in imitation, since the imitator often must decide whether to do something effectively or else in the way a demonstrator has done it. It also plays a role in some collaborative activities in which the goal is not just that something be done but that it be done together with someone else. Basically, the state of the world the organism seeks to bring about – its goal – may include just about anything in particular cases, including self-action and joint action with others.

This is our model of intentional action. But our concern is not with the question of whether organisms themselves produce intentional actions, which many do, but rather it is with the question of how they understand the intentional actions of others. Our special concern is with human ontogeny and when and how this understanding emerges.

2. Understanding intentional action

The classic studies of children's understanding of intentions are studies in which adults ask preschool children explicit verbal questions about various kinds of actions – for example, successful, accidental, and unsuccessful – and they respond verbally. For example, Piaget (1932) presented children with stories in which a child did things either "on purpose" or "by accident" and asked about blameworthiness and the like. In other studies, children observe actions and then are asked specific questions about the goals and intentions of the actors (e.g., see Baird & Moses 2001; Smith 1978; Shultz & Wells 1985). Recently, the focus has been on whether children distinguish desires (or goals) from intentions (or plans), and the general finding is that they can do so in their explicit language from about 5 years of age (e.g., see Feinfeld et al. 1999; Schult 2002). Also interesting are studies in which preschool-age children talk about artifacts and artwork in terms of the intentions of those who produced them (e.g., see Bloom & Markson 1998; Gelman & Ebeling 1998).

But children actually begin to demonstrate an understanding of intentional action long before this, during infancy, and our primary concern is with these ontogenetic origins. Even in the first year or so of life, we may distinguish three levels in children's understandings of the actions of others (here and throughout the observer is *she* and the actor is *he*).

Acting animately. An observer perceives that the actor has generated his motion autonomously; that is, she distinguishes animate *self-produced* action from inanimate, caused motion. There is no understanding that the actor has a goal, and so means and ends are not distinguished, nor are successful and unsuccessful actions. Although observers may learn from experience what animate actors typically do in familiar situations, predicting behavior in novel circumstances is basically impossible. (In the format of Fig. 1, inside the actor's head is nothing.)

Pursuing goals. An observer perceives and understands that the actor has a goal and behaves with *persistence* until reality matches the goal; that is, she understands that the actor recognizes the success or failure of his actions with respect to the goal and continues to act in the face of failure. This understanding implies that the observer also knows that the actor *sees* things (e.g., objects with respect to which he has goals, potential obstacles to goals, the results of actions) and that this helps to guide action and determine satisfaction with results. Understanding action in this way enables observers to predict what actors will do in at least some novel situations. (In the format of Fig. 1, inside the actor's head is a goal and perceptual monitoring.)

Choosing plans. An observer perceives and understands that the actor considers action plans and *chooses* which of them to enact in intentional action (and these may be more or less rational depending on their fit with perceived reality). She also understands that in acting toward a goal the actor chooses which entities in its perceptual field to *attend to*. In general, the observer understands that actors act and attend to things for reasons, which enables her to predict what an actor will do in a wide variety of novel situations. (All elements of Fig. 1 present.)

Children's understanding of these different aspects of intentional action and perception emerge, in this order, at different points in infancy.

2.1. Understanding animate action

Infants recognize self-produced, biological motion within a few months after birth (Bertenthal 1996), and they soon turn to look in the same direction as other persons as well (D'Entremont et al. 1997). By around 6 months of age, infants have developed sufficient expectations about human animate action to be able to predict what others will do in familiar situations. Thus, for example, using an habituation methodology, Woodward (1998) found that infants of this age expect people (specifically, human hands) to do such things as reach for objects they were just reaching for previously. Infants do not expect inanimate objects that resemble human hands (e.g., a garden-tool "claw") to "reach" toward the familiar object in similar circumstances.

This and similar studies are sometimes interpreted as demonstrating that 6-month-olds see human actions as goal directed (e.g., see Woodward 1999). From our perspective, a more felicitous appellation would be object directed; that is, infants in these studies clearly expect the adult to be consistent in his interactions with the same object over a short span of time, and they follow gaze to the object he is looking at. But to do these things, infants need only to understand that people spontaneously produce behavior (they are animate beings) and to have some familiarity with what people typically do in familiar circumstances; they do not need to have any understanding of the internal structure of

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intentional actions. For example, they do not need to know that the actor is evaluating the efficacy of his action toward a goal and persisting in his behavior until he is successful – much less that he chooses an action to enact intentionally for "rational" reasons.

2.2. Understanding the pursuit of goals

By 10 months of age, infants segment streams of continuous behavior into units that correspond to what adults would see as separate goal-directed acts (Baldwin et al. 2001). Infants of this same age also look to an adult's face when he teases her with a toy or obstructs her play with a toy (Carpenter et al. 1998b; Phillips et al. 1992) – perhaps suggesting that infants are seeking information about the adult's goal by trying to discern where he is looking or his emotional state.

But more than segmenting actions and trying to identify goals, infants of this age also demonstrate an ability to understand an actor's persistence to a goal – which involves an understanding that actors perceptually monitor and recognize when their actions have changed the world in the desired way. This is clearest in the case of actions that are not immediately successful, because in this case the child must infer the actor's goal even though it is not achieved (and therefore not observed) from various aspects of behavior and context. The two main categories of unsuccessful actions are trying and accidents.

First, infants' understanding of trying is evident in the well-known series of habituation studies by Gergely and colleagues involving obstacles (Csibra et al. 1999, 2002; Gergely et al. 1995). In the classic study, infants were habituated to a large dot "jumping" over an obstacle and approaching a small dot. Later, with the obstacle gone, 9- and 12-month-olds (but not 6-month-olds) dishabituated to the same jumping motion (even though its path of movement was identical to that during habituation), and they did not dishabituate to the large dot going directly to the small dot (even though this was a new motion). The argument is that infants remained habituated to the different motion in this latter condition because they saw the large dot's actions as in some sense the same as during habituation: goal-directed and efficient action to the small dot. It thus seems that 9- to 12-month-old infants understand at least one aspect of trying: actors routinely go around obstacles to get to goals.

In a more interactive methodology, Behne et al. (2005) engaged infants in a game in which an adult gave them toys across a table. Interspersed were trials in which the adult held up a toy but did not give it over. In some cases this was because he was unwilling, in various ways, and in other cases it was because he was trying but unable, in various ways (e.g., could not extract it from a container). In reaction to these activities, 9- to 18-month-olds, but not 6-month-olds, showed more signs of impatience (e.g., reaching, turning away) when the adult kept the toy for himself than when he was making a good faith effort to give it over. Infants thus seemed to have appreciated that in the unable scenarios the adult was, for example, trying to give them a toy as he struggled unsuccessfully against the recalcitrant container. Interestingly, 15-month-old and older infants can even imagine the specific goal an actor is trying to attain as he struggles unsuccessfully – as evidenced by the fact that when they observe unsuccessful actions they imitate not those specific movements but rather they make attempts to reproduce the actor's desired result in the environment using novel actions (Bellagamba & Tomasello 1999; Johnson et al. 2001; Meltzoff 1995).

The second way that infants display an understanding of the persistent nature of goal-directed activity is when they distinguish purposeful actions from accidental actions, knowing that an accidental action will not satisfy the actor's goal. Thus, in the Behne et al. study, another pair of conditions involved an adult either holding out a toy in a teasing fashion (unwilling) or holding out a toy but dropping it accidentally (unable). In reaction to these two different adult goals, 9-month-old (and older) infants, but not 6-month-old infants, were more impatient when the adult was teasing them than when he was simply being clumsy. The earliest age at which children first understand accidental actions thus matches the age at which they first understand trying actions (as determined by two different experimental paradigms): 9 months, but not 6 months. Relatedly, Carpenter et al. (1998a) found that 14- to 18-month-old infants chose to imitate purposeful but not accidental actions.

When 9-month-olds begin to understand that actors are pursuing goals, they must know also that the actor perceives his actions and their results. Only if infants understand this can they understand why the actor is satisfied or disappointed after completing an action. So in addition to 6-month-olds' gaze following, it is important that 12-month-olds (younger infants have not been tested) follow the direction of adult gaze in more complex situations, for example, to locations behind barriers (Moll & Tomasello 2004). This behavior goes beyond simple gaze following, because the infant does not just respond to a head turn by turning her own head in the same direction, but she actually has to locomote some distance to attain the appropriate viewing angle – indicating an understanding that the adult sees something that she does not (see also Caron et al. 2002 for studies in which infants in this same age range know that the adult's visual access is impeded by barriers).

A reasonable conclusion from all of this is thus that 9- to 12-month-old infants understand the basics of goal-directed action. They understand that actors try to achieve goals, that they keep trying persistently after failed attempts and accidents and around obstacles, and that when they succeed they stop acting toward the goal – which involves an understanding that people perceptually monitor their actions so that they can recognize when they have succeeded. But this is still not all that can be known about intentional action.

2.3. Understanding the choice of plans

In the months immediately following their first birthdays, infants begin to understand that, in pursuing a goal, an actor may consider various action plans (means) and chooses one to enact in intentional action based on some reason related to reality. There is only one study demonstrating such understanding in young infants. It involves so-called rational imitation.

Gergely et al. (2002) showed 14-month-old infants an adult touching his head to the top of a box to turn on a light. However, for half of the infants, the adult's hands were occupied during this action (he was shivering and holding a blanket around his shoulders) and, for the other half, the adult's hands were free during the action. In both condi-

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tions, infants thus saw that the adult was trying to turn on the light with his head. Nevertheless, when it was their turn (and they had no blanket around their shoulders), infants who saw the hands-free demonstration bent over and touched the box with their heads more often than did infants who saw the hands-occupied demonstration. Apparently, infants assumed that if the adult's hands were free and he still chose to use his head, then there must be a good reason for this choice – he intended to turn on the light with his head – and so they followed suit. However, if the adult's hands were occupied, then the use of the head was explained away as necessary given his circumstance – without the constraint of the blanket he would not have chosen this means – and so they were free to ignore it since the same constraint was not present for them. In this study, therefore, infants understood not just that the actor perceived and evaluated the efficacy of his actions to a goal, but rather infants understood that the actor perceived and evaluated reality rationally before choosing an action plan designed to accommodate this reality in pursuit of the goal.[2]

In terms of the understanding of perception, infants at this age seem to have an understanding of at least some aspects of selective attention. Tomasello and Haberl (2003) had an adult say to 12- and 18-month-old infants "Oh, wow! That's so cool! Can you give it to me?" while gesturing ambiguously in the direction of three objects. Two of these objects were "old" for the adult – he and the child had played together with them – and one was "new" to him (though not to the child). Infants gave the adult the object that was new for him. This suggests that they understood that even though the adult was looking at and seeing all three objects equally, he was selectively attending only to the one that he had not previously experienced and so now wanted. One interpretation of this result is that infants understand perception as a kind of rational action also, in the sense that from all the things they see people choose to attend to only a subset, and they do this for reasons related to their goals.

2.4. Cultural learning

The developmental picture that emerges is thus as follows. Six-month-old infants perceive animate action and follow gaze direction, which enables them to build up experiences on the basis of which they predict people's actions in familiar contexts. By 9 months of age, infants understand that that people have goals and persist in behaving until they see that their goal has been reached (avoiding obstacles and persisting past accidents and failures in the process) – being happy when the goal is reached and disappointed if it is not. By 14 months of age, infants begin to understand full-fledged intentional action – including the rudiments of the way people make rational decisions in choosing action plans for accomplishing their goals in particular reality contexts and selectively attending to goal-relevant aspects of the situation.

This kind of understanding leads to some powerful forms of cultural learning, especially imitative learning in which the observer must perform a means-ends analysis of the actor's behavior and say in effect "When I have the same goal I can use the same means (action plan)." This analysis is also necessary before one can ask why someone did something and whether that reason also applies in my circumstance ("rational imitation"). Without such an analysis, only simpler forms of social learning are possible (Tomasello et al. 1993, and see sect. 4.1.1). The main point is that 1-year-old infants use their newly emerging skills of intention understanding not only to predict what others will do, but also to learn from them how to do things conventionally in their culture.

3. Shared intentionality

When individuals who understand one another as intentional agents interact socially, one or another form of shared intentionality may potentially emerge. Shared intentionality, sometimes called "we" intentionality, refers to collaborative interactions in which participants have a shared goal (shared commitment) and coordinated action roles for pursuing that shared goal (Gilbert 1989; Searle 1995; Tuomela 1995). The activity itself may be complex (e.g., building a building, playing a symphony) or simple (e.g., taking a walk together, engaging in conversation), so long as the interactants are engaged with one another in a particular way. Specifically, the goals and intentions of each interactant must include as content something of the goals and intentions of the other. When individuals in complex social groups share intentions with one another repeatedly in particular interactive contexts, the result is habitual social practices and beliefs that sometimes create what Searle (1995) calls social or institutional facts: such things as marriage, money, and government, which only exist due to the shared practices and beliefs of a group.

According to Bratman (1992), joint cooperative activities, as he calls them, have three essential characteristics that distinguish them from social interaction in general (here modified slightly): (1) the interactants are mutually responsive to one another, (2) there is a shared goal in the sense that each participant has the goal that we (in mutual knowledge) do X together, and (3) the participants coordinate their plans of action and intentions some way down the hierarchy – which requires that both participants understand both roles of the interaction (*role reversal*) and so can at least potentially help the other with his role if needed. Some aspects of this account of shared intentionality are translated into our diagrammatic conventions in Figure 2.

Note two things about Figure 2, which is meant to depict each participant's understanding of the interaction. First and most important, the cognitive representation of the goal contains both self and other; that is, it contains not only the self's goal that the box be open, but also the self's goal that this be accomplished with the partner. One might simply say, then, that his goal concerns their mutual actions. But since he does not have expectations about the partner's particular behaviors, but rather about her intentional actions (as defined by goals such as opening the box), we may better say that the actor wants his interactant to have, along with him, the goal of opening the box – which she should pursue using whatever means are necessary. And of course the partner, assuming she also desires collaboration, also wants her partner to share her goal – thus creating a "shared commitment" (Gilbert 1989). And so, overall, this figure instantiates our claim that there is a special kind of shared motivation in truly collaborative activities in the form of a shared goal – each interactant has goals with respect to the other's goals – a crucial point to which we return later in differentiating human collaboration and intentional communication from the social interactions of other primate species.[3]

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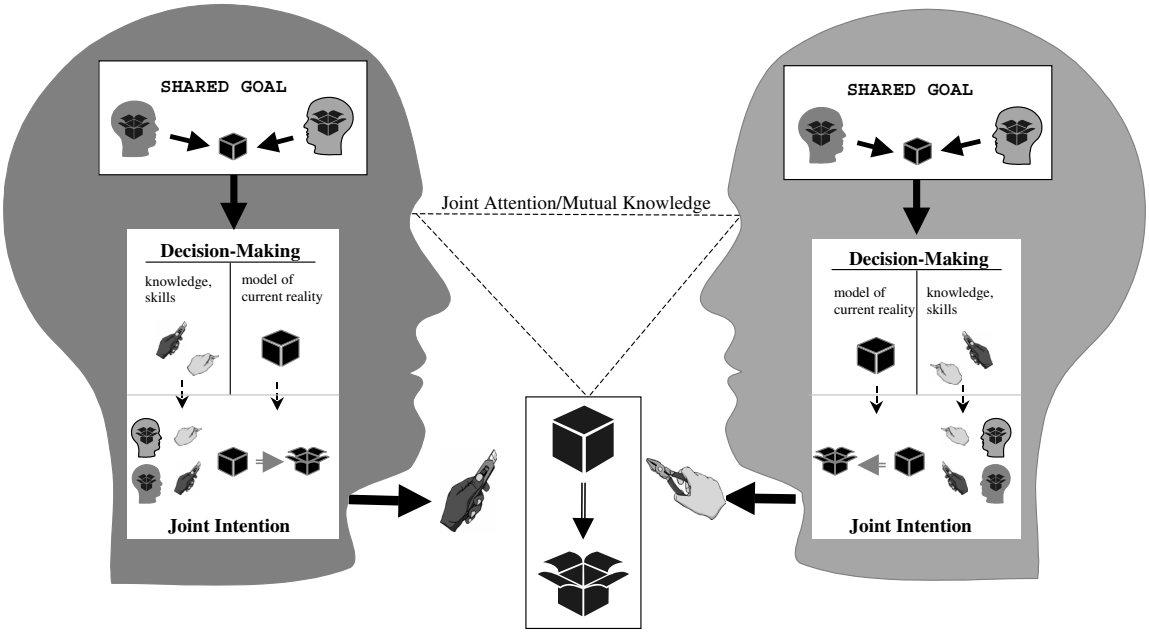

Figure 2. Each partner's conception of a collaborative activity in which a shared goal and joint intention (with complementary roles) are formed.

The second important aspect of this figure is that the cognitive representation of the intention also contains both self and other – it is thus a joint intention. This is necessary because both collaborators must choose their own action plan in the activity in light of (and coordinated with) the other's action plan: my role is to hold the box steady while you cut it open. This requires that each participant cognitively represent both roles of the collaboration in a single representational format – holistically, from a "bird's-eye view," as it were – thus enabling role reversal and mutual helping. Overall, then, collaborative activities require both an alignment of self with other in order to form the shared goal, and also a differentiation of self from other in order to understand and coordinate the differing but complementary roles in the joint intention.

In the first year or so of life, human infants socially interact with other persons in various ways leading gradually to more or less full participation in activities involving shared intentionality.

Dyadic engagement: Sharing behavior and emotions. An individual interacts with, and is mutually responsive to, an animate agent directly – mainly through the expression of emotions and behavioral turn taking. (In the format of Fig. 2, nothing inside the heads.)

Triadic engagement: Sharing goals and perception. An individual interacts together with a goal-directed agent toward some shared goal. In doing this, both interactants perceptually monitor the goal-directed behavior and perceptions of the partner. (In the format of Fig. 2, inside the heads are shared goals and perceptual monitoring.)

Collaborative engagement: Joint intentions and attention. An individual interacts with an intentional agent toward some shared goal and with coordinated action plans as manifest in a joint intention – and with joint attention (mutual knowledge) as well. Each interactant thus cognitively represents both the shared goal and action plans involving complementary roles – with the possibility of reversing roles and/or helping the other in his role, if necessary. (In the format of Fig. 2, all components present.)

These different types of social engagement – which emerge in human ontogeny in this order – depend on particular ways of understanding intentional action in general: as animate, goal directed, or intentional, as elaborated in the previous section. In addition, however, they also rely – in a way to be explained now – on a special motivation to share psychological states with other persons.

3.1. Dyadic engagement: Sharing behavior and emotions

Human infants are extremely sensitive to social contingencies. In their face-to-face interactions with adults, infants from just a few months of age display the ability to take turns in the sense of acting when the adult is more passive and being more passive when the adult is acting (Trevarthen 1979). When these contingencies are broken – for example, in experiments in which the adult's behavior is preprogrammed (or played to the infant over delayed video) – infants show various signs of being out of sorts (for reviews, see Gergely & Watson 1999 and Rochat & Striano 1999). Infants' early social interactions thus clearly show mutual responsiveness on the behavioral level.

But there is another dimension to these interactions that goes beyond simple timing and contingency. Human infants and adults interact with one another dyadically in what are called *protoconversations*. These are social interactions in which the adult and infant look, touch, smile, and vocalize toward each other in turn-taking sequences. But as most observers of infants have noted, the glue that holds protoconversations together is not just contingency but the exchange of emotions (Hobson 2002; Trevarthen 1979). Evidence for this comes from Stern (1985), who found that during protoconversations adult and infant do not just mimic each other or respond randomly, but often express

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the same emotion using a different behavior (e.g., the adult expresses happiness facially and the child vocally). During protoconversations, infants gaze into the eyes of the partner face-to-face in what is called *mutual gazing*. It is a dyadic activity in the sense that the infant is not monitoring the adult's looking at her or any other object; it is direct engagement.

Although there may be differences in the way protoconversations take place in different cultures – especially in the nature and amount of face-to-face visual engagement – in one form or another they seem to be a universal feature of adult-infant interaction in the human species (Keller et al. 1988; Trevarthen 1993). Protoconversations require not only that the two interactants understand each other as animate agents, but also that they have a special motivation and capacity to share emotions with each other. This additional factor is clearly necessary, as the individuals of many nonhuman species appreciate others as animate agents, but are still unmotivated to engage with them in protoconversations (see sect. 4.1.2 on great apes). But sharing emotions in early infancy is just the beginning of a much longer developmental process. Important though they may be as a foundation, protoconversations do not involve joint commitments to any shared goals or action plans.

3.2. Triadic engagement: Sharing goals and perception

At around 9 to 12 months of age, as infants are beginning to understand other persons as goal directed, they also begin to engage with them in activities that are triadic in the sense that they involve child, adult, and some outside entity toward which they both direct their actions. These are activities such as giving and taking objects, rolling a ball back and forth, building a block tower together, putting away toys together, "pretend" games of eating or drinking, "reading" books, and pointing-and-naming games (Hay 1979; Hay & Murray 1982; Verba 1994). During these activities, infants' looking becomes coordinated with that of the other person triadically toward the relevant outside objects as well. When researchers focus on this aspect of the joint activity, it is most often called "joint attention" (e.g., see papers in Moore & Dunham 1995) – what we will call at this level joint perception.

The question from the point of view of shared intentionality is how the infant understands her engagement with the adult while participating in these initial triadic activities. For instance, suppose a child and adult are building a block tower together. Possibly the child just ignores the adult and places her blocks on the tower irrespective of what the adult is doing; this is not triadic but individual activity. Or perhaps the child is only responsive to the adult in the sense of taking turns; there is no shared goal but only mutual responsiveness. But perhaps adult and child have created a shared goal to build the tower together. This shared goal serves to coordinate their activities around the same object triadically and thereby to enable each participant to know something about what the other is perceiving and to predict what she will do next. The interaction is thus more than sharing behavior or emotions dyadically; it is sharing goals and perceptions with respect to some external entity triadically. Although the evidence is less than fully compelling, Ross and Lollis (1987; see also Ratner & Bruner 1978) observed that, starting at around 9 months of age, infants do a number of things to attempt to reengage a recalcitrant adult in joint activities – such things as handing him an object or gesturing to him to show continued interest in playing the joint game – perhaps suggesting a goal to engage in the activity together (*shared goal*).

Thus, at 9 months of age, infants' special motivation to feel and act and perceive together with others takes on a new form. As infants begin to understand other persons as pursuing goals, their "doing together" with them becomes truly triadic, and the two of them begin to actually share goals as they act together to change the state of the world in some way and to perceive the world together in acts of joint perception. Although nonhuman animals may engage with one another in complex social interactions in which they know the goals of one another and exploit this, they are not motivated to create shared goals to which they are jointly committed in the same way as humans (such that they would be upset if the other reneged; see sect. 4.1.2 on apes). But once again, this is not all that human infants do; there is still further development. Triadic engagements with shared goals still do not necessarily require infants to plan together with others or to coordinate with them the specific intentional actions that will serve as complementary roles in their collaboration.

3.3. Collaborative engagement: Joint intentions and attention

At around 12 to 15 months of age, infants' triadic engagements with others undergo a significant qualitative change. In a classic longitudinal study, Bakeman and Adamson (1984) categorized infants' interactions with their mothers as involving, among other things, either "passive joint engagement" or "coordinated joint engagement." Passive joint engagement referred to triadic interactions in general, whereas coordinated joint engagement referred to triadic interactions in which the infant was much more active in the interaction – not just following adult leads, but also sometimes directing adult behavior and attention as well in a more balanced manner. The empirical finding was that although 9-month-old infants engaged in much passive joint engagement, it was not until 12 to 15 months of age that infants engaged in significant amounts of coordinated joint engagement.

One possible explanation for this change is that soon after their first birthdays infants begin to understand the specific action plans of other persons and something of how they are chosen (as outlined in sect. 1), and they use this understanding in their triadic activities with them. This means, for instance, that the child understands that in pursuing the shared goal of building a block tower the adult holds the edifice steady while she, the child, places blocks. Infants of this age not only share goals but also coordinate roles.

Potential evidence for this interpretation is again provided by Ross and Lollis (1987), who observed that when an adult stopped participating in shared activities, from about 14 months of age infants not only prompted him to reengage, but they sometimes even performed the recalcitrant adult's turn for him. This might suggest that infants of this age understand not only the shared goal but also the two roles involved, and they are motivated to help the adult in his role. Also relevant is the experimental study of Carpenter et al. (2005). They set up situations in which an adult did things like hold out a basket in which the child should

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place a toy. After the child complied, the adult then placed the basket in front of the child and held the toy himself. Some 12-month-olds, and even more 18-month-olds, then took their turn by holding out the basket for the adult and, importantly, looked to him in anticipation of his placing something in it. It thus seems that after an initial encounter in one role of an interaction, infants often understand the other role – an exchanging of roles that may be called *role-reversal imitation* (see also Ratner & Bruner 1978). One possible explanation for the qualitative shift in infants' social engagements soon after the first birthday, then, is that they are in the process of developing a deeper understanding of intentional action in terms of underlying plans and intentions, and their motivation to share then leads them to create with others not only shared goals but also joint intentions with coordinated roles.

In these interactions, infants are of course also coordinating their perceptions with others, what we will call at this stage joint attention – indicating that infants know that others choose what to attend to within their perceptual fields (as evidenced, for example, by the study by Tomasello & Haberl 2003; see sect. 2.3). It is also at around this same age that infants make their first nascent attempts to establish joint attention actively with others through gestures such as pointing. Of special interest, of course, is declarative pointing in which infants direct adults' attention seemingly for the sole motive of sharing attention. Thus, when an adult reacts to the pointing of a 12-month-old by simply looking to the indicated object, or by looking to the infant (emoting positively), or by doing nothing, infants are not satisfied – implying that these were not their goal. But when an adult responds by looking back and forth from the object to the infant and comments positively, infants are satisfied – implying that this sharing of attention and interest was their goal (Liszkowski et al. 2004). Infants of this age will also sometimes point simply to inform adults of things, even though they themselves have no direct interest in them – a kind of helping motive (Liszkowski et al., in press; see also Kuhlmeier et al. 2003, who found that 12-month-olds discriminate actions in which one computer-animated dot either "helps" or "hinders" another one up an incline). One-year-olds thus seem to have as goals both joint attention itself and also helping others to attain their goals by directing their attention in relevant ways.

Many of these new aspects of triadic interactions come together in a major new accomplishment of children soon after their first birthdays: language. Language, in the sense of linguistic communication, typically begins in earnest at around 13 to 14 months of age. In some theoretical perspectives, language is itself an inherently collaborative activity (Clark 1996) – in at least two senses. First, linguistic symbols are inherently collaborative; they are bidirectional coordination devices, comprising the two implicit roles of speaker and listener. In learning to use symbols, children learn to play both roles and to comprehend both roles no matter which they are playing. Learning symbols thus involves role-reversal imitation (using symbols toward others the way they have used them toward you), and it also involves taking shared perspectives on things and learning that people can choose to attend to things and construe them in many different ways as needed (Clark 1997; Tomasello 1999b).

Second, conversation is an inherently collaborative activity in which the joint goal is to reorient the listener's intentions and attention so that they align with those of the speaker, and joint intentions serve to do that through various kinds of collaborative acts. For example, the speaker collaborates by expressing his communicative intentions in ways that are potentially comprehensible by the listener, even clarifying (helping) when necessary; and the listener collaborates by making good-faith attempts at comprehension by following the speaker's attention-directing signals, making appropriate and relevant inferences, and asking for clarification (help) when needed. Importantly, from their earliest forays into linguistic communication, infants engage in a "negotiation of meaning" in which they request clarification from the adult and produce communicative repairs for the adult when needed (Golinkoff 1993). All of this takes place and is socially structured within the common cognitive ground of various kinds of joint attentional formats (Bruner 1983; Tomasello 1999b) – which make some aspects of entities in the shared situation "mutually manifest" and so potentially "relevant" for acts of interpersonal communication (Sperber & Wilson 1986)

By 12 to 14 months of age, then, the triadic interactions of child and adult around external entities appear as more "coordinated joint engagement," since the child can do such things as reverse roles and help the adult in her role if needed – both necessary for engaging in joint actions embodying joint intentions. In beginning to acquire linguistic symbols at this age, infants again demonstrate an understanding of the different but complementary roles in a social interaction – in this case an interaction involving the exchange of communicative intentions embodied in conventionalized actions – and they are motivated simply to share experience with others and help them toward their goals.

3.4. Cultural creation

And so human infants seem to have from very early in ontogeny a very strong motivation to share emotional states with others, and before the first birthday they express motivations for sharing goals and perceptions with others. By about 12 to 14 months of age, the motivation to share with others reaches down past the sharing of goals and perceptions and into the infant's and others' chosen plans of action and attention: they form joint intentions and participate in joint attention. This means that the child and adult not only construct a shared goal, but they also establish mutually supportive roles by coordinating and sometimes even planning what each will do as they act together toward a common end, attending to things jointly as they do. Children are thus engaging not just in cultural learning, which depends on understanding others as intentional agents, but rather, by formulating joint goals and intentions, they are engaging in full-blooded cultural creation. Perhaps of special note in this regard, 1- to 2-year-old children also begin participating in collaborative pretense activities in which they and the adult create together a shared fictional reality based on their joint intentions and attention (Rakoczy et al., 2005).

The cognitive representations underlying truly collaborative activities must contain at least two hierarchical levels: a higher one for the shared goal and a lower one for the joint intentions – with at least two sets of action plans (roles) in the joint intentions. This means that the cartoons of Figure 2 are meant to be taken seriously. Human cognitive representations may include people and their intentional actions

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in the world, including joint intentions between self and other. As these are, in essence, representations of social engagements, we may call them "dialogic cognitive representations" (Fernyhough 1996). Dialogic cognitive representations are necessary not only for supporting certain forms of collaborative interactions on-line, but they are also necessary for the creation and use of certain kinds of cultural artifacts, most importantly linguistic and other kinds of symbols, which are socially constituted and bidirectional. Dialogic cognitive representations may be ontogenetically emergent in the sense that the individual interacts in certain ways with other intentional agents, and then internalizes these interactions (see sect. 5.2).

Importantly, dialogic cognitive representations pave the way for later cognitive achievements that may be called, very generally, "collective intentionality" (Searle 1995). That is, the essentially social nature of dialogic cognitive representations enables children, later in the preschool period, to construct the generalized social norms (e.g., truth) that make possible the conceptualization of individual beliefs and, moreover, to share those beliefs. Sharing beliefs is responsible for the creation of social-institutional facts such as money, marriage, and government, whose reality is grounded totally in the collective practices and beliefs of a social group conceived generally (Tomasello & Rakoczy 2003). Importantly, when children internalize generalized collective conventions and norms and use them to regulate their own behavior, this provides for a new kind of social rationality (morality) involving what Searle (1995) calls "desire-independent reasons for action."

4. Apes and children with autism

An interesting question in all of this is the manner in which our nearest primate relatives are able to understand and share intentions. Obviously, an answer to this question would help to shed light on the phylogeny of social cognition in the human species, but it also would help to shed light on its ontogeny as well – by providing a kind of general primate starting point that might serve to isolate the evolutionarily unique features of human social cognition. Children with autism, who do not understand or interact with other persons in the species-typical manner for biological reasons, provide another perspective on the process from the point of view of atypical development, which can also quite often help us to carve nature at its joints.

4.1. Great apes

4.1.1. Understanding intentional action. Nonhuman primates are clearly able to use a variety of cues to predict the behavior of others in familiar situations, and even to try to influence their behavior communicatively, which suggest that they understand conspecifics as animate agents who produce their behavior spontaneously (Tomasello & Call 1997). Experimentally, using the Woodward habituation paradigm (as reviewed in Section 2.1), Santos and Hauser (1999) found that some monkeys expect that people continue to reach for an object that they have previously gazed at – just like human infants.

With regard to the understanding of goal-directed action, there is currently a good bit of controversy. Povinelli and Vonk (2003) consider the understanding of goals and perceptions to be an instance of understanding mental states, and their view is that apes understand only behavior not mental states. In contrast, Tomasello et al. (2003) (revising the view expressed in Tomasello & Call 1997) argue that there are now new data which compel us to attribute to great apes the ability to understand intentional action in terms of goals and perceptions.

Of most importance, it seems that apes understand both trying and accidents, in which the desired result never happens (see sect. 2.2). With regard to trying, Call et al. (2004) tested chimpanzees in a food-giving context similar to that of the Behne et al. study with human infants (described in Section 2.2). Specifically, a human began giving food to an ape through a hole in a Plexiglas wall, but then sometimes brought out a piece of food and either refused to give it to the ape (unwilling) or else attempted to give it to the ape unsuccessfully (unable). Similar to human 9- and 12-month-olds, chimpanzees gestured more and left the area earlier when the human was unwilling than when he was unable – in which case they tended to wait patiently throughout his well-meaning but unsuccessful attempts. The chimpanzees apparently understood the behavior of the human in the unable conditions as persistent attempts (trying) to give them food.[4]

With regard to accidents, comparisons of one pair of conditions in the Call et al. (2004) study also suggested that apes understand when someone is trying to give them something but clumsily failing. That is, apes also waited patiently when the human was making a good-faith, but clumsy and unsuccessful, effort. In addition, Call and Tomasello (1998) tested apes' ability to distinguish purposeful from accidental actions in a different paradigm. They trained subjects to associate a marker situated on top of one of three opaque buckets with the location of hidden food. In test trials, a human then placed the marker on one of the buckets purposefully, but either before or after this he let the marker fall accidentally onto one of the other buckets. Apes as a group chose the bucket that had been marked purposefully.

Chimpanzees also understand that others see things. They follow conspecific gaze direction to external targets (Okamoto et al. 2002; Tomasello et al. 1998), they check back with the looker (and eventually quit looking) if nothing is there (Call et al. 1998; Povinelli & Eddy 1996; Tomasello et al. 2001), and they even follow the gaze direction of humans to targets behind barriers (Tomasello et al. 1999). Chimpanzees also know that what others see affects what they do. Thus, Hare et al. (2000, 2001) placed a dominant and a subordinate individual into competition with each other over food – with some pieces of food visible to both individuals and some visible only to the subordinate chimpanzee. By pursuing most often the piece of food hidden from the dominant's view, subordinates demonstrated that they knew what the dominant could and could not see. And, importantly, the subordinates knew what this meant for the dominant's goal-directed action: if the dominant could see the food or had seen it just before, subordinates could infer that she would go for it (whereas they would not make this inference if what she saw was instead a rock). It is noteworthy that a monkey species did not behave like chimpanzees in the Hare et al. (2000) paradigm, and so perhaps this understanding is confined to apes (Hare et al. 2003).

It would thus seem that, at least on one reasonable read-

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ing of the data, some great apes understand at least some aspects of intentional action and perception. Apes understand that others have goals and behave toward them persistently, and that this is governed by what they perceive. This is still not an understanding of the more mental dimensions of intentional action, however – specifically those that have to do with the decision-making process by which the actor generates action plans and, based on a rational assessment of reality, chooses one to enact in intentional action. There is so far no evidence that apes understand this more mental dimension of the process, but at the moment there are no good tests of this – especially since imitation is not a very good way of investigating apes' social cognition. Indeed, many studies of imitation have shown that in response to a demonstration, apes tend to reproduce the result in the environment (*emulation learning*) and pay very little attention to the actual intentional actions of the demonstrator (see Tomasello 1996 for a review). This failure to engage in humanlike processes of cultural learning may be considered further evidence that apes are not so attuned to action plans or intentions.

4.1.2. Shared intentionality. Despite this sophistication in understanding many important aspects of intentional action, apes still seem to lack the motivations and skills for even the most basic forms of sharing psychological states with others. Thus, while ape infants interact with their mothers dyadically and are responsive to them behaviorally (Maestripieri & Call 1994) and they may even show some maternal gazing and social smiling (Mizuno & Takashita 2002; Tomonaga et al. 2004), there are no observations of anything like protoconversations between adults and infants. Personal observations of the authors suggest that although all primates display similar social emotions in terms of attachment between babies and mothers, human infants and mothers possess a much larger behavioral repertoire for expressing a much wider range of emotions in their social interactions than do other apes (e.g., laughing, crying, cooing, smiling) – especially expressions of positive emotions serving to enrich the dyadic emotional engagement between mother and child.

Similarly, apes engage in very few triadic interactions with others around objects. They beg food from one another, and youngsters' play sometimes incorporates objects. But systematic observations of chimpanzee and bonobo mothers and infants with objects reveals very little triadic engagement, and none that appears to involve a shared goal (Bard & Vauclair 1984; Tomonaga et al. 2004). When apes interact with humans, they engage in more triadic interactions, but these interactions are still discernibly different from those of human mothers and babies. For example, Carpenter et al. (1995) observed human 18-month-olds as well as chimpanzees and bonobos in interaction with an adult human and some objects. In this situation, all three species interacted with objects and simultaneously monitored the adult human's behavior reasonably frequently. However, there were also important differences. Human infants spent far more time in joint attentional episodes, and their looks to the face of the adult were, on average, almost twice as long as those of the apes. Infant looks were also sometimes accompanied by smiles, whereas apes do not smile. These differences gave the impression that the ape's look to the adult was a checking look (to see what the adult was doing or was likely to do next), whereas the infant's look to the adult was a sharing look (to share interest). One interpretation of this pattern of observations is that although apes know that others have goals and perceptions, they have little desire to share them. They can interact with others triadically around objects, but they do not engage with others in shared endeavors with shared goals and experiences.

With regard to collaborative engagement, chimpanzees join one another in agonistic interactions within the group (so-called coalitions and alliances), and they act together to defend the group from predators and other chimpanzee groups. But in these interactions each individual does basically the same thing, they just do it in concert without any discernible coordinated plans. The most complex cooperative activity of chimpanzees is group hunting, in which two or more males seem to play different roles in corralling a monkey (Boesch & Boesch 1989). But in a reinterpretation of participant behavior over time in these hunts, some observers have characterized this activity as essentially identical to the group hunting of other social mammals such as lions and wolves (Cheney & Seyfarth 1990; Tomasello & Call 1997). Although it is a complex social activity, as it develops over time each individual simply assesses the state of the chase at each moment and decides what is best for it to do. There is nothing that would be called collaboration in the narrow sense of joint intentions and attention based on coordinated plans. In experimental studies (e.g., see Crawford 1937; Chalmeau 1994), the most complex behavior that can be extracted is something like two chimpanzees pulling a heavy object in parallel, and during this activity almost no communication among partners is observed (Povinelli & O'Neill 2000). There are no published experimental studies – and several unpublished negative results (two of them ours) – in which chimpanzees collaborate by playing different and complementary roles in an activity.

In general, it is almost unimaginable that two chimpanzees might spontaneously do something as simple as carry something together or help each other make a tool, that is, do something with a commitment to do it together and to help each other with their role if needed. Indeed, in a recent study, Hare and Tomasello (2004) found that in a single food-finding task structured as either competition or cooperation, chimpanzees performed much more skillfully in the competitive version. Nor does ape communication seem to be collaborative in the same way as human communication. Most basically, there is very little communication about third entities (topics), and there are no signals serving a declarative or informative motive. Apes do not point, show, or even actively offer things to conspecifics.[5] Also, Tomasello (1998) argues and presents evidence that chimpanzee signals are not really bidirectional in the sense that sender and receiver both know that either could play either role (i.e., they do not know it is the same signal when they send it as when they receive it).[6] There are also a number of experimental studies demonstrating that apes are not able to understand communicative intentions as manifest in such acts as pointing or placing a marker to indicate the location of food (for a review, see Call & Tomasello, 2005). Finally, in no case does there seem to be any kind of negotiating over intended meaning, requests for clarification, or other kinds of negotiation (Liebal et al., 2004). In general, although chimpanzee groups in the wild do have different behavioral "traditions" (Boesch 1996), chimpanzees' relatively modest skills of collaboration would not seem to be

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of the type necessary for cultural creation of the human kind.

The overall conclusion would thus seem to be that although apes interact with one another in myriad complex ways, they are not motivated in the same way as humans to share emotions, experiences, and activities with others of their own kind. They do not look to others and smile in order to share experience triadically, they do not invite others to share interest and attention via declarative gestures, they do not inform others of things or help them in their efforts, and they do not engage with others in collaborative activities with shared goals and joint intentions. But what if they are raised in a human cultural environment in which they are encouraged to engage in collaborative activities and communicate with symbols? The basic answer is that apes raised in such environments become more like humans than their wild conspecifics, but they do not turn into humans (Call & Tomasello 1996). Thus, Savage-Rumbaugh (1990) reports that the bonobo Kanzi participates regularly in social activities such as preparing food and playing with toys. But it is not clear whether he has the kind of commitment to these activities as joint endeavors that characterizes human collaboration, and there is no evidence that he understands the role of the other or supports him in it. In his mainly imperative attempts at communication, Kanzi does not simply share interest with or inform others, and he does not negotiate over meaning or support the other collaboratively in the communication process through requests for clarification or adjustments for listener knowledge (Greenfield & Savage-Rumbaugh 1991).

4.2. Children with autism

4.2.1. Understanding intentional action. Children with autism clearly understand other persons as animate beings who produce behavior spontaneously, as evidenced by their social behavior in general. In addition, in the few nonverbal studies that have been conducted, these children show some signs of understanding that others have goals and that others see things. Thus, 3- to 4-year-old children with autism look more to an adult's face following ambiguous actions than unambiguous actions – presumably in an attempt to discern the adult's goal (Carpenter et al. 2002; Charman et al. 1997; though see Phillips et al. 1992 for a negative finding). Using imitation tasks, Carpenter et al. (2002) found that 3- to 4-year-old children with autism not only imitated an adult's unusual action, such as turning on a light with the head, but also looked to the light in anticipation, seemingly indicating their appreciation of the goal-directed nature of this action. With regard to trying, two studies using versions of Meltzoff's (1995) behavioral reenactment procedure found no clear impairment for children with autism (Aldridge et al. 2000; Carpenter et al. 2001), suggesting their appreciation of the persistent nature of goal-directed action. Findings are mixed with regard to the cultural learning skills of children with autism (e.g., see Rogers 1999 for a review). But Hobson and Lee (1999) found that children with autism imitated the particular style of a demonstrator's actions less often than did other children. This might suggest, among other things, that they are less skilled at analyzing intentional action down the hierarchy of means.

In terms of an understanding of perception, children with autism show clear deficits in tests of spontaneous gaze following, but, interestingly, when instructed to do so, they can report what the other person is looking at (Leekam et al. 1997). There are, to our knowledge, no direct tests of their ability to follow gaze around barriers or in any other way to demonstrate whether they understand that others do not just look at things but actually see or attend to things. One plausible hypothesis, then, is that at least some children with autism (perhaps on the high-functioning end of the spectrum) understand that others have goals and behave toward them persistently (and that others see things). However, they still may not understand the decision-making process by which an actor rationally chooses among potential behavioral means to generate intentional action; this has not been explicitly tested as yet.

4.2.2. Shared intentionality. Unfortunately, the skills children with autism have for understanding intentional action and perception do not translate into motivations and skills for sharing psychological states with others – with even the name of the disorder suggesting this deficit. With regard to shared dyadic engagement, Hobson (2002) reviews much evidence that children with autism have special problems in recognizing, understanding, and sharing emotions with others, and so they do not seem to engage in protoconversations.

Deficits with regard to shared triadic engagement and joint attention are so pervasive in children with autism that they actually represent diagnostic criteria. Perhaps of special importance, children with autism show very little coordinated joint engagement, and initiate very few bids for joint attention with others by declaratively pointing to or showing objects (e.g., see Baron-Cohen 1989; Charman et al. 1997; Mundy & Willoughby 1996) – which indicates most clearly their lack of motivation. They also rarely respond to others' bids for joint attention (e.g., see Leekam et al. 1997). With regard to collaborative engagement, children with autism engage in relatively little cooperative play with peers and in general collaborate with others very little (Lord 1984), and there is little evidence of role reversal or helping others in their role (Carpenter et al. 2005). Linguistic communication and the use of symbols is another problem area for children with autism, and their impaired ability to signal noncomprehension and make appropriate repairs to their own linguistic messages to help others are well documented – suggesting that their communication is not fully collaborative (Loveland et al. 1990). Hobson (2002) argues and presents evidence that in fact all of these problems may be traced back to problems with emotional relatedness, that is, a deficit in the normal human motivation to share emotions, experiences, and actions with other persons. The outcome is that, although there may be a few unusual individuals, the vast majority of children with autism do not participate in the cultural and symbolic activities around them in anything like the normal way.

4.3. Summary

Great apes and children with autism are clearly not blind to all aspects of intentional action. Contrary to some previous accounts, both apes and some children with autism do appear to understand actions as goal directed if not fully intentional; that is, they understand that others have goals, persist toward them, and perceptually monitor the process. This means that both of them show some skills of social

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learning, though not as powerful or pervasive as those of human 1- and 2-year-olds. However, neither apes nor children with autism follow the typical human developmental pathway of social engagement with other persons. Neither of them engages with other persons in shared dyadic engagements (protoconversations), shared triadic engagements (joint actions), or collaborative engagements (with joint intentions and attention). And there does not seem to be anything like a declarative motivation simply to share attention with others or to inform others or to help others, anywhere in sight. In general, it seems that neither apes nor children with autism have – at least not to the same extent as typically developing human children – the motivation or capacity to share things psychologically with others. This means that they both have very limited skills for creating things culturally with other persons.

5. Two hypotheses

Based on all of these data, our proposal is that in addition to understanding others as intentional, rational agents, humans also possess some kind of more specifically social capacity that gives them the motivation and cognitive skills to feel, experience, and act together with others – what we may call, focusing on its ontogenetic endpoint, shared (or "we") intentionality. As the key social-cognitive skill for cultural creation and cognition, shared intentionality is of special importance in explaining the uniquely powerful cognitive skills of *Homo sapiens*. And so our question now is Where does this capacity for shared intentionality come from phylogenetically and ontogenetically?

5.1. A phylogenetic hypothesis

Primates are intensely competitive creatures. By most accounts, the social-cognitive skills that distinguish primates from other mammals evolved mainly in the context of competitive social interactions, and so, following Humphrey (1976), primate social cognition has been characterized by appellations such as primate politics (de Waal 1982) and Machiavellian intelligence (Byrne & Whiten 1988). In experimental comparisons, at least some primate species show their most sophisticated social-cognitive skills in competitive rather than in cooperative situations (Hare and Tomasello 2004; Hare et al. 2000; 2001).

Our proposal is that, in addition to competing with others (and coordinating with others generally, like all social animals), humans evolved skills and motivations for collaborating with one another in activities involving shared goals and joint intentions/attention. At some point – perhaps heralding the emergence of modern humans some 150,000 years ago – individuals who could collaborate together more effectively in various social activities came to have a selective advantage. This may have happened within groups, in a manner analogous to the hypothesis of Wrangham (1980), who argues that because many primates forage for patchy resources such as fruit, and patchy resources may be easily dominated by a small group of individuals to the exclusion of others, some primates have evolved social systems in which small groups (e.g., matrilineal kin groups as well as more temporary coalitions and alliances) act together so as to compete with groupmates for valued resources (see also van Schaik 1989). Humans may simply have pushed this process – small bands acting together to compete with other bands in their group – a bit further by turning "acting together" into collaborating. But the evolution of humans' unique skills of collaboration may also have happened between groups. Thus, it is also possible that some kind of group-level selection played an important role in the evolution of these collaborative activities, as some change in the ecology of *Homo* made it more likely that entire groups with many collaborators outcompeted other groups with fewer collaborators (Sober & Wilson 1998).

The key cognitive substrate required for skillful collaboration is the ability to read intentions. Although intention reading may be helpful in competitive interactions, it is not absolutely necessary – since in competition I care mainly about what you *do*. That is to say, in competitive interactions, the interactants do not have goals about others' intentional states; the situation is that we both have the "same" goal (e.g., we both want that piece of food), and the key thing is that I anticipate what you will do next. In contrast, collaborative interactions require interactants to have goals about others' intentional states so that the requisite shared goals and plans may be formulated. Thus, in collaborative interactions, we are faced with the so-called coordination problem from the outset: to even get started, we must somehow coordinate or negotiate so that we end up with a shared goal (which we did not have to start with; see Levinson 2000). Then, in addition, to collaborate effectively, we must mesh our action plans at least some of the way down the hierarchy – and this requires some communication about those plans, at least to some degree ahead of time.

Phylogenetically, it is possible that the selection process favoring collaborative individuals worked on variation in intention reading of the type currently represented in the great apes. But, more likely, earlier members of the genus *Homo* developed especially complex skills of intention reading in the context of the imitative learning of complex tool-using and tool-making activities – which require a hierarchical analysis of goals and plans – so that the selection process on modern humans was working with individuals already especially adept at discerning the intentional structure of action. This account would also explain why it is that modern humans seem to be so much more skillful at imitation than other apes – especially when the task requires a means-ends analysis of the observed behavior (Tomasello 1996).

The key motivational substrate required for collaboration is the motivation to share feelings, experiences, and activities with other persons – where again sharing means having psychological states that include within them as content the psychological states of others. Perhaps following Hare and Wrangham (2002), we might propose a first step of increased within-group tolerance, as humans (and to some degree bonobos) essentially "domesticated" themselves relative to the *Pan-Homo* common ancestor of 6 million years ago – ostracizing overaggressive and less-tolerant groupmates. But this is not enough. In addition, collaborative activities require more active motivations for sharing emotions, experience, and intentional actions with others. For example, communicating only to share interest in things and communicating only to share information seem to be uniquely human activities (what Dunbar 1996 calls gossiping), and imitation for purely social motivations – not just to accomplish goals but to be like others – is a key com-

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ponent in the transmission of human culture (Tomasello 1999b). In addition, it may even be that humans have some "altruistic" motives for helping others in the sense that they are motivationally built for strong reciprocity, in which their behavior is governed by social norms of "fairness" (Boyd et al. 2002; Gintis et al. 2003).[7] Again, it is possible that the selection process favoring collaborative individuals worked on variation in the motivation to share of the type currently represented in other apes. But it is also possible that by the time this selection process took place, *Homo* had already evolved some new social motivations, perhaps in the context of nuclear families (Wrangham et al. 1999).

We thus envision that the individuals of some premodern human population, possessing something like modern-day chimpanzee "culture" (Boesch 1996), evolved the skills and motivations of shared intentionality, which enabled especially complex forms of collaboration and resulted eventually in modern human cultural organization. It is possible that individual selection could do the whole job, as in many cases collaborative actions have mutualistic benefits to both participants. Or there may also have been, in addition, some form of group-level selection (Sober & Wilson 1998) or cultural group selection (Boyd et al. 2002), relying on social norms of strong reciprocity and cultural conformity. The coevolution of skills of intention reading and collaboration then enabled – via cultural-historical processes involving the ratchet effect – creation of the many collective artifacts and social practices that constitute particular human cultures and that structure the cognitive ontogenies of developing youngsters. Our proposal thus supplements a Machiavellian account of human cognitive evolution, which emphasizes only competition, with a Cultural account that emphasizes in addition the importance of collaboration, cultural-historical processes, and strong reciprocity based on social norms.

5.2. An ontogenetic hypothesis

If our phylogenetic hypothesis is correct, selection for good collaborators means selection for individuals who are (1) good at intention reading and (2) have a strong motivation to share psychological states with others. Our ontogenetic hypothesis is that it is precisely these two developing capacities that interact during the first year of life to create the normal human developmental pathway leading to participation in collaborative cultural practices.

As for the first, intention-reading, line of development, there have been a number of proposals to the effect that this skill is a hardwired and modular part of the human perceptual system. Just as humans automatically see certain perceptual sequences as causal (Leslie 1984; Michotte 1963), they automatically see certain actions performed by animate agents as goal directed. Gergely and Csibra (2003) have proposed that human infants possess an action-interpretation system that perceives humanlike action as teleologically directed to a goal from the second half of the first year of life; independently developing is a reference-interpretation system concerned with following gaze and the like (Csibra 2003). Baron-Cohen (1995) proposes something similar, with two early developing innate modules involving the perceiving of goals and eye gaze direction. Soon after the first birthday, a "shared attention mechanism" emerges, taking the two earlier modules as inputs.

Although our view shares some features with these views, there are two important differences. First, we do not see infants' understanding of goals/intentions and perception/attention as blocked off from each other in a modular fashion. Indeed, much of the evidence we have presented here suggests that in attempting to understand what others are doing and why they are doing it, infants comprehend intentional action and perception as an integrated system (i.e., as a kind of control system). They display such an integrated understanding from 9 months of age when they know that an actor pursues goals persistently (until he perceives that the world matches his goal) and also engage with other persons triadically around external objects – where they must infer people's perceptions from their goals and their goals from their perceptions. In general, we do not see how an observer can understand goal-directed action (much less rational action) without understanding a perceiving organism who monitors the world for signs of success, failure, obstacles, and so forth.

Second, we believe that to understand the origins of a human cognitive skill we must go beyond simply labeling it as "innate." Indeed, although we concur that understanding actions as goal directed is a biological adaptation, this says nothing about the ontogenetic process. It is very unlikely, in our view, that a human or ape kept in social isolation for the first year of life would suddenly understand others as goal-directed or intentional agents on its initial encounter with them; presumably, the developmental pathway for understanding intentional action depends on species-typical social interactions early in ontogeny. This does not necessarily mean, however, any specific experiences. Thus, Kaye (1982) proposes that to understand intentions infants must themselves be treated by adults as intentional, in the sense that adults interpret their actions in adultlike terms and provide various types of feedback to this effect. The problem with this more specific hypothesis is that there seems to be fairly wide cultural variation in how infants are treated by adults – with adults in some cultures not really treating infants as fully intentional – and, by all accounts, all children in all cultures develop an understanding of others as intentional agents.

As for the second, sharing, line of development, theorists such as Trevarthen (1979), Bråten (2000), and especially Hobson (2002) have elaborated the interpersonal and emotional dimensions of early human ontogeny in much more detail than we have here. We mostly agree with their accounts, but we find that they do not give sufficient attention to the other, intention-reading, line of social-cognitive development. Our proposal is that the uniquely human aspects of social cognition emerge only as uniquely human social motivations interact with an emerging, primate-general understanding of animate and goal-directed action – which then transforms the general ape line of understanding intentional action into the modern human line of shared intentionality.

Although the precise nature of this interaction is not entirely clear, our general view is that infants begin to understand particular kinds of intentional and mental states in others only after they have experienced them first in their own activity and then used their own experience to simulate that of others (Tomasello 1999b; for experimental evidence supporting this view, see Sommerville & Woodward 2005). However, contrary to our previous view, we do not think that simple "identification with others" is a sufficient basis for the simulation process – certainly not if we mean

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bodily identification, as there is now evidence that neonatal chimpanzees engage in the same kind of facial mimicking as human infants (Myowa 1996; Myowa-Yamakoshi et al. 2004), and even some species of birds are good at copying actions (e.g., see Zentall 1996). And so we would speculate at this point that more deeply psychological levels of identification with others – of a kind sufficient to enable individuals to simulate the intentional and mental states of others on analogy with their own – depend crucially on the skills and motivations for interpersonal and emotional dyadic sharing characteristic of human infants and their caregivers (Hobson 2002).

Again, one can imagine that a species-typical social environment, involving human-typical social interactions with other persons, is required for the emergence of the sharing motivation and its related skills of social engagement. But, again, some theorists have proposed that some kinds of specific experiences are necessary. For instance, Stern (1985) proposes that parents must "mirror" back to infants their own emotions or behaviors, and Gergely (2001) posits an especially important role for certain kinds of social contingencies in terms of timing. But, again, it is not clear that children in all cultures receive such experiences, or that children who are deprived of them end up unable to share psychological states with others. And so the ontogenetic process for sharing emotions and intentions with others may be fairly robust in the face of different particular human social environments.[8]

Based on this analysis and on our review of the developmental research in Sections 2 and 3, then, our proposal for the early developmental pathway characteristic of human social cognition is thus:

- Young infants understand other persons as animate agents and so share emotions and engage with them dyadically;
- 9-month-olds understand other persons as goal-directed agents and so share goals (and perception) and engage with them triadically; and
- 14-month-olds understand other persons as intentional agents and so share intentions (and attention) and engage with them collaboratively (so creating, via internalization, dialogic cognitive representations).

This pathway is a synergistic product of the general ape line of understanding intentional action, unfolding from 0 to 14 months, and the modern human motivation to share psychological states with others, present from very early in human ontogeny. Figure 3 provides a schematic overview of this account. As noted above in this section, there has been almost no research – not even training studies or correlational studies – that establishes a solid relationship between any kind of particular social experience infants might have and individual differences in the unfolding of this developmental pathway. In the absence of such studies, we might tentatively conclude that this is a very robust, heavily canalized ontogenetic pathway in humans that emerges in all "normal" human environments.

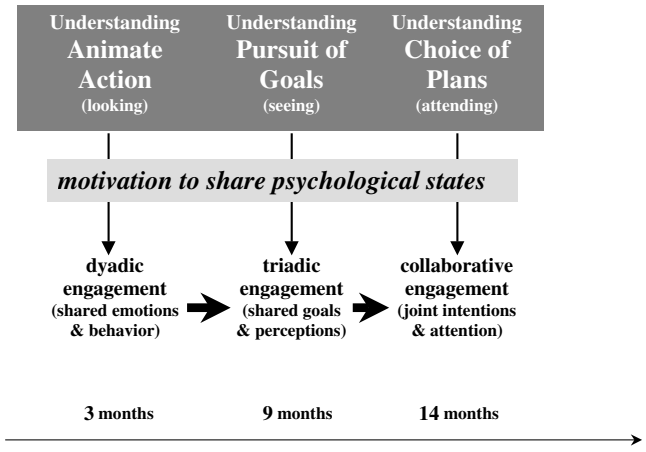

Figure 3. Ontogenetic pathway for human social engagement as a joint product of the understanding of intentional action and the motivation to share things with others psychologically.

What results from this developmental process, early in the second year of life, is a new form of cognitive representation, what we have called dialogic cognitive representations, and they enable children's participation in truly collaborative cultural practices such as linguistic communication and other forms of symbolic interaction. Dialogic cognitive representations include and go beyond theoretical constructs such as "identification with others" (Hobson 1993; Tomasello 1999b), the "like me" stance (Meltzoff & Gopnik 1993), and "self-other equivalence" (Barresi & Moore 1996) – which may be ontogenetic forerunners. That is to say, they capture the fact that the child both knows that she is in some sense equivalent to others – actors can substitute for one another in acts of imitation and role reversal – but at the same time she is different from others. Dialogic cognitive representations thus have built into them the functional equivalence (though not identity) of different participants in activities, one of whom may be the self, but they have additional aspects (e.g., intentions about the other's intentions) deriving from the motivation to share psychological states with others.

At this point, we are in no position to offer a specific hypothesis about how dialogic cognitive representations are created ontogenetically beyond the general claim that the sharing of psychological states engaged in by human infants and caregivers is in some way internalized in Vygotskian fashion. Perhaps a bit more specifically, we might hypothesize that in understanding an adult's intentional actions, including those directed toward her, at the same time that she experiences her own psychological states toward the other, the child comes to conceptualize the interaction simultaneously from both a first and third person perspective (see Barresi & Moore 1996) – forming a "bird's-eye view" of the collaboration in which everything is comprehended in a single representational format.[9] During months and even years of such interactions, from ages 1 to 5 and beyond, children come to construct in dialogic fashion such things as social norms and their constitutive conventional practices and individual beliefs. This enables them to participate in and contribute to the collective social practices and institutions around them, that is, to participate in and contribute to the collective intentionality of a human culture.

6. Conclusion

Human cognition sticks out like an elephant's trunk, a giraffe's neck, a peacock's tail. It is one form of primate cognition, but it seems totally unique as people go around talking and writing and playing symphonies and doing math and building buildings and engaging in rituals and paying bills

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and surfing the web and creating governments and on and on. Also unique in the animal kingdom, human cognition is highly variable across populations, as some cultures have complex foraging and navigational techniques whereas others have very few of these, and some do algebra and calculus whereas others have very little need for complex mathematics. And so the biological adaptation we are looking for is one that is rooted in primate cognition but then provides humans with the cognitive tools and motivations to create artifacts and practices collectively with members of their social group – that then structure their and their offspring's cognitive interactions with the world. We are thus looking for a small difference that, by creating the possibility of culture and cultural evolution, made a big difference in human cognition.

Our proposal for this "small difference that made a big difference" is an adaptation for participating in collaborative activities involving shared intentionality – which requires selection during human evolution for powerful skills of intention reading as well as for a motivation to share psychological states with others. In ontogeny, these two components – the understanding of intentional action and the motivation to share psychological states with others – intermingle from the beginning to produce a unique developmental pathway for human cultural cognition, involving unique forms of social engagement, symbolic communication, and cognitive representation. Dialogic cognitive representations, as we have called them, enable older children to participate fully in the social-institutional-collective reality that is human cognition.

There are two other main theoretical contenders for what makes human cognition unique in the animal kingdom. First, of course, many theorists point to language, and without a doubt language must play a central role in all discussions of the evolution of human cognition. But saying that only humans have language is like saying that only humans build skyscrapers, when the fact is that only humans (among primates) build freestanding shelters at all. Language is not basic; it is derived. It rests on the same underlying cognitive and social skills that lead infants to point to things and show things to other people declaratively and informatively, in a way that other primates do not do, and that lead them to engage in collaborative and joint attentional activities with others of a kind that are also unique among primates. The general question is What is language if not a set of coordination devices for directing the attention of others? What could it mean to say that language is responsible for understanding and sharing intentions, when in fact the idea of linguistic communication without these underlying skills is incoherent. And so, while it is true that language represents a major difference between humans and other primates, we believe that it actually derives from the uniquely human abilities to read and share intentions with other people – which also underwrite other uniquely human skills that emerge along with language such as declarative gestures, collaboration, pretense, and imitative learning (Tomasello 2003). Of course, later in ontogeny, there may be some cognitive achievements possible only with the support of the linguistic version of dialogic cognitive representations, which embody in special ways the different perspectives and construals that people may take on things (Lohmann et al., 2005).

The other major contender for what makes human cognition unique is theory of mind. Our proposal is of course one variant of this, and indeed we would argue that the full understanding of intentional action, including its rational and normative dimensions, involves some understanding of things mental. But when most people use the term theory of mind they mean the belief-desire psychology with which school-age children and adults operate. But this form of theory of mind is clearly derivative of more basic social-cognitive skills. Thus, Tomasello and Rakoczy (2003) argue and present evidence that while the understanding and sharing of intentions emerges ontogenetically in all cultural settings at around 1 year of age – with no known individual differences due to environmental factors – the understanding of beliefs emerges some years later at somewhat different ages in different cultural settings, and there is very good evidence that participating in linguistic communication with other persons (especially some forms of perspective-shifting discourse) is a crucial, perhaps even necessary, condition for its normal development. And so again, while the understanding of beliefs and desires is clearly a critical component in uniquely human cognition and culture, we do not believe it is basic, but rather it, too, is derived from the understanding and sharing of intentions.

Having argued that an adaptation for shared intentionality is more basic than other theoretical contenders such as language and theory of mind, we must also acknowledge that there could be other hypotheses about the origins of uniquely human cognition that are more basic still. For example, one could hypothesize that humans simply evolved larger brains with more computing power than other primates – maybe specifically a larger working memory that enables them to hold more things in mind simultaneously (e.g., see Olson & Kawamar 1999) – and that this was sufficient to create all the differences we see today between humans and other primates. Also, one could hypothesize a very simple difference in sociality between humans and other animals, such as the tendency to be responsive to the rewards, punishments, and direction of others in the social group (e.g., see Wilson 1999 on consilience). But in these cases we would argue that such nonspecific adaptations are not sufficient to get the job done. To get from primate social groups to human cultures and the collective cognition they embody, something like an adaptation for participation in collaborative activity is required – leading to selection for motivations and skills of shared intentionality and the cultural-historical processes these engender.

There is of course still much we do not know about all of this. We do not know with much precision the degree to which humans and other apes differ in their understanding of how others choose plans – the rational aspects of intentional action – since most of the studies done with infants cannot be so easily done with apes. We have very little specific knowledge about humans' motivation to share things psychologically with others, in this case because the most telling experiments (e.g., isolation experiments) would be unethical. We do not know exactly how much of an understanding of intentional action is necessary for children to participate in collaborative activities. And conversely, we do not know whether the kinds of collaborative activities that exist in cultures before children are born are a necessary or only a facilitative component in the ontogenetic process – or whether they play no effective role at all at the outset (though clearly they play a crucial role later). Our view is that to make progress on these and related questions we must focus our research efforts both on the individual cog-

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nitive skills required to understand intentional action, in all its many dimensions, and also, in equal measure, on the social motivations and dialogic representations that underlie the collaborative activities and collective artifacts that structure human culture and cognition.

NOTES

1. Note that in a situation in which current reality matches the desired goal state, the organism will not behave (it will have no desire to behave because its goal is already met). It is also possible that, in some cases, inaction is a good strategy for bringing the world in line with one's goals. That is, in some cases, inaction may be intentional action, an insight possible only if one considers all of the components of a control system working together.

2. This study – or any other with its same logic – has yet to be done with younger children. It might be argued that the study by Gergely et al. (1995) showed that infants know that organisms adjust their behavior to reality constraints in the form of obstacles. But the dishabituation methodology does not enable such an inference because the child does not have to choose an action plan herself (as in imitation studies). Thus, in that study, infants only needed to discriminate normal from abnormal behavior: goal-directed agents do not normally take circuitous routes to goals. (A similar argument applies to the study by Woodward & Sommerville 2000.)

3. In some accounts of shared intentionality, it is enough that we both have the same goal and know that we do (i.e., have mutual knowledge of the fact that we both have the same goal). But this is not enough; we might each want the box open and know that the other does also, but still not form a shared goal (perhaps we will compete to see who can open it). Further, it is also not enough simply to have goals about our behaving together. If I suggest we go to the movie together, my desire is not that you come because your mother forced you to but because you want to – I want us to have a shared commitment. (Note, however, that because of the hierarchical structure of action, there may exist many mixed cases in which you collaborate reluctantly because of competing goals and so forth.)

4. In a different experimental paradigm, Myowa-Yamakoshi and Matsuzawa (2000) and Call et al. (2005) both used Meltzoff's (1995) behavioral reenactment procedure (involving trying and failed attempts) with chimpanzees. Both found that chimpanzees, like children, performed the target action equally as often when they saw a failed attempt as when they saw the completed action. However, in both studies, chimpanzees also performed the target action at high levels in a baseline condition containing no demonstration at all, which seriously limits what can be concluded about the subjects' understanding of the modeled action.

5. Vervet monkey alarm calls and the like do not need to be interpreted as referential, and indeed individuals have very little control over their production at all (Owren & Rendell 2001). Moreover, there is no evidence that any ape species uses such calls (Tomasello & Call 1997).

6. Although sometimes presented in this way, the study by Povinelli et al. (1992) has other interpretations not involving role reversal (Tomasello & Call, 1997).

7. Evidence for this view is provided by experimental studies in paradigms such as (1) the ultimatum game in which individuals offer more money to others than would be beneficial from a selfish viewpoint, at least partly because this seems like the "fair" thing to do (Gintis et al. 2003); and (2) experimental games in which individuals go to great lengths to punish others who are not being "fair" even when this punishing act could not possibly lead to future benefits for the punisher that outweigh the costs (on altruistic punishing, see Fehr & Gächter 2002).

8. That is, at least with respect to basics – specific environmental differences may of course create important individual differences, some considered atypical or even pathological.

9. Barresi and Moore (1996) are focused on a different problem, claiming that in order to attribute psychological states to others at all the infant must first interact with them in situations in which they both have similar psychological reactions. We are focused on collaboration and dialogic cognitive representations among agents who already understand one another intentionally, and our hypothesis is that the child internalizes these interactions into cognitive representations that encompass simultaneously both first-person and third-person perspectives.

Open Peer Commentary

Language first, then shared intentionality, then a beneficent spiral

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Abstract: Tomasello et al. give a good account of how shared intentionality develops in children, but a much weaker one of how it might have evolved. They are unduly hasty in dismissing the emergence of language as a triggering factor. An alternative account is suggested in which language provided the spark, but thereafter language and shared intentionality coevolved.

Nobody could dispute Tomasello et al.'s major premise – that shared intentionality forms the basic infrastructure of the uniquely human capacity to collaborate. Nor would one argue against their conclusion that apes possess at least the rudiments of intentionality, plus a spot of primitive mind reading (although parents of autistic children may not be too happy about having them compared with apes). The authors are right to look for a missing, uniquely human ingredient.

But in their search for such an ingredient they walk right over it at the very beginning. In their introduction, they state that collaborative acts are "structured by shared symbolic artifacts, such as linguistic symbols and social institutions, facilitating their 'transmission' across generations." The question that immediately arises is whether language merely structures these acts and facilitates their transmission, or whether it is itself the missing ingredient, both a necessary and sufficient condition for the capacities at issue. If so, looking for another cause would violate Occam's razor.

We are told that we are biologically adapted for shared intentionality, but the authors devote most of the target article to an ontogenetic rather than a phylogenetic analysis, and offer only a skeleton outline of the evolutionary processes involved. Some of the developmental studies they cite are indeed impressive; perhaps most of all that by Tomasello and Haberl (2003), which suggests we should take another look at accounts claiming children under age 4 have no theory of mind. However, unless one swallows Haeckel wholesale, there are no grounds for assuming that the ontogenetic order of the developments described precisely mirrors that of their phylogenetic emergence.

Indeed, when the authors attempt an evolutionary account, they are reduced to implausible just-so stories. It is suggested that early humans may have merely intensified a primate trait in which small bands competed for scarce resources, leading to greater intragroup cooperation, or that some "change in the ecology of *Homo*" caused groups that contained more collaborators to outcompete groups that contained fewer. What scarce resources? What change in ecology? Why did humans, rather than any of the other primate species, begin to collaborate? Why did their collaboration grow to such a vast extent while other primates still do not

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collaborate at all? No answers are provided. Moreover, there is not one shred of evidence in the entire paleontological record for the kind of scenario sketched here.

But some such scenario was more or less forced on the authors by their decision that language could not have been the missing ingredient. In section 6, they make the bald assertion that "Language is not basic; it is derived." They ask, "What is language if not a set of coordination devices for directing the attention of others?" Well, any number of things, but most importantly an entirely novel means of structuring experience and representing the world (Bickerton 1990).

It is claimed that the notion of linguistic communication without understanding and sharing intentions is incoherent. But what about protolinguistic communication (Bickerton 1990)? The authors would be right if the understanding and sharing of intentions, on the one hand, and language, on the other, had suddenly emerged ready-made; if we did not understand and share intentions the way we do now, language as we know it now would indeed be unworkable. But none of these things dropped from the skies in their current state. All evolved, presumably from very humble beginnings, and it is in dealing with these beginnings that the article is weakest.

The word *coevolution* is tossed around pretty freely these days, but here is where a really strong case could be made for it. Very little understanding or sharing of intentions – perhaps little if any beyond what contemporary apes possess – would have been required to comprehend and act on the kind of single-unit utterances with which language must have begun. (Or do the authors propose that our ancestors suddenly started spouting full grammatical sentences, like the infant Lord Macaulay?) But once the process began, every increment in linguistic skill could lead to an increase in shared intentionality, and vice versa.

The question is, of course, a chicken-and-egg one. Did language trigger shared intentionality, or vice versa? One interesting difference between the two lies in the fact that shared intentionality had primate precursors, whereas language didn't. Tomasello et al. themselves list some of those precursors in section 4.1.1; the differences between apes and children that they point out in section 4.1.2 are mainly matters of degree. Language, however, differed radically and qualitatively from anything that had gone before. It seems plausible to suppose that the radical difference triggered the spurt in the more scalar one rather than vice versa.

A commentary with a thousand-word cap hardly gives room to flesh out an alternative scenario. However, I would urge the authors to consider the kind of coevolutionary account I have merely hinted at here. When all is said and done, is it too trivially obvious to ask what force could have driven shared intentionality more effectively than the ability to tell one another our intentions?

Joint cooperative hunting among wild chimpanzees: Taking natural observations seriously

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Abstract: Ignoring most published evidence on wild chimpanzees, Tomasello et al.'s claim that shared goals and intentions are uniquely human amounts to a faith statement. A brief survey of chimpanzee hunting tactics shows that group hunts are compatible with a shared goals and intentions hypothesis. The disdain of observational data in experimental psychology leads some to ignore the reality of animal cognitive achievements.

In the past, philosophers and scientists have regularly proposed new definitions of human uniqueness based on their personal convictions and intuitions of what animals are or are not able to do. Nowadays, over 45 years of field studies on wild chimpanzees provide a wealth of observational data against which to confront these preconceptions. In this sense, it is more than surprising to find only a single reference to animal field data in Tomasello et al.'s long citation list. Not surprisingly, their portrayal of cooperative hunting in chimpanzees reminds one of the old philosophers' claims. This is especially disappointing in that their proposition that the ability to share goals and intentions is a uniquely human capacity rests squarely on the assumption that no other species can do so.

I will briefly outline an analysis of the hunting behaviour among wild chimpanzees showing that individual hunters' behaviour is noticeably compatible with sharing goals and intentions. Hunting has been observed in all chimpanzee populations studied so far, and large differences in hunting strategies have been documented, especially in the propensity to hunt in collaborative groups (Boesch 1994a; 1994b; Mitani & Watts 1999; 2001; Nishida et al. 1992; Stanford 1998; Stanford et al. 1994a; 1994b; Watts & Mitani 2000; 2002). Natural observations can address only the question of performance, but we know from human observations that comprehension often exceeds performance (Birch & Bloom 2004; Keysar et al. 2003). During 77% of the 274 group hunts followed, Taï chimpanzees performed four complementary hunting roles (Fig. 1). Briefly: The *driver* initiates the hunt by slowly pushing the arboreal prey in a constant direction, *blockers* climb trees to prevent the prey from dispersing in different directions, the *chaser* may climb under the prey and by rapidly running after them try a capture, and the *ambusher* may silently climb in front of the escape movement of the prey to block their flight and close a trap around the prey (Boesch 1994a; 2002; Boesch & Boesch-Achermann 2000). Hunting success increases with the number of hunters, so that large groups in which all roles are performed are very successful (63 to 89% of captures achieved). During such collaborative hunts, each hunter synchronizes and spatially coordinates his movements to those performed by others, and sometimes anticipates their future actions. Each individual hunter can perform most complementary roles and individuals may even shift roles during a given hunt, demonstrating a capacity for role reversal and perspective taking. Tomasello et al. suggest that a chimpanzee hunter "simply assesses the state of the chase at each moment and decides what is best for it to do." However, drivers and ambushers achieve only 1% and 11% of the captures respectively, while 81% are achieved by individuals following the hunt from the ground. Consequently, drivers are granted about three times less meat than captors of the prey (Boesch 2002; Boesch & Boesch-Achermann 2000). Interestingly, ambushers that anticipates movements of the prey and the other hunters are granted an amount of meat equal to captors, even when they have not made the capture.

Thus, under a selfish hypothesis, chimpanzees should only wait on the ground for the prey to fall or perform the ambusher role that guarantees more meat. Group hunting would become rare. This is not the case as Taï chimpanzees hunt about 250 times per year (Boesch & Boesch-Achermann 2000). On the other hand, a joint goal hypothesis seems more compatible with the observations, with individual hunters assessing whatever role needs to be performed for the joint hunt and able to flexibly perform the roles needed independently of their short-term benefit. Like in a team of soccer players, individuals react opportunistically to the present situation while taking in account the shared goal of the team. Some players will rarely make a goal, like defenders and goalies, but the success of the team will critically depend upon their contribution. This is very reminiscent to group hunting in chimpanzees where synchronization of different coordinated roles, role reversal, and performance of less successful roles favor the realization of the joint goal. Thus, the group hunting behaviour of the Taï chimpanzees fulfills the criteria set by Tomasello et al. for shared goals and intentions. I am not claiming that chimpanzees perform like humans; I am merely emphasizing that the evidence published on hunting in chimpanzees is compatible with the scenario of shared goals and intentions proposed by Tomasello et al.

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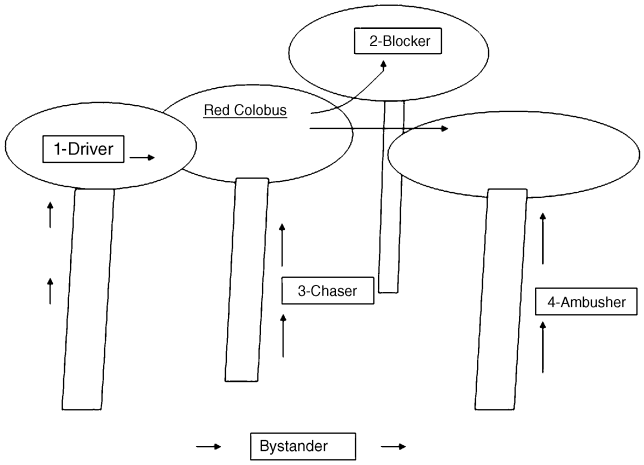

Figure 1 (Boesch). Illustration of a "typical" joint collaborative hunt in Taï chimpanzees indicating the spatial coordination of the different roles. The numbering indicates the approximate order in which the roles are joining into the hunt.

and therefore not a distinct human feature. One possible difference might be that human soccer players sometimes explicitly plan movements or strategies before the play starts and we have not yet seen this kind of shared planning in chimpanzees.

In the broader interest of the field of comparative psychology one further aspect is worth addressing: Why did Tomasello et al. ignore the published evidence on wild chimpanzee group hunting? Such an attitude is far from being isolated as illustrated by the conspicuous scarcity of reference to observations on wild animals in some of the cognitive literature claiming human superiority (e.g., Evans 2003; Heyes 1994; 1998; Povinelli 2000; Tomasello 1999). Generally, there is a tendency in comparative psychology to accept only experimental data. Observational data are dismissed as mere anecdotes or are discredited as not conclusive because alternative scenario could always been constructed. However, if we want to understand the specificity of cognitive abilities in humans and chimpanzees we have to take in account what they do in real life. Such data are irreplaceable as they provide the necessary information about how human and non-human primates perform. My point is not that field data answer all the questions about mental processes. What I am suggesting is that we need to formulate our hypothesis about human uniqueness in terms of performance that we should confront to the known performance of animals. The outcome could then be used as a guide for the aspects requiring more evidence, including experimental studies. Had that been done in Tomasello et al.'s article, I would probably have had no critical comment to forward on shortcomings or premature conclusions.

ACKNOWLEDGMENT
The author wants to thank Hedwige Boesch, Josep Call, and Peter Walsh for helpful comments.

Early development of shared intentionality with peers

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Abstract: In their account of the origins of human collaborative abilities, Tomasello et al. rely heavily on reasoning and evidence from adult–child collaborations. Peer collaborations are not discussed, but early peer collaborations differ from early adult–child collaborations. Describing and explaining the similarities and differences in shared intentionality with peers and adults will bring us closer to understanding the developmental mechanisms.

What are the origins of human collaborative abilities? Tomasello et al. hypothesize that humans possess a species-unique motivation to "feel and act and perceive together with others." This special motivation to share intentions, combined with intention understanding acquired in the context of adult–child collaborations, is proposed to drive the genesis of collaborative activity. By this account, at the end of the first year of life human infants are able to understand others' emotions, perceptions, intentions, goals, and plans. And, because they are uniquely motivated to share their psychological states with others – that is, to represent others' psychological states in concert with their own – human infants are able to collaborate with others and become, effectively, members of and contributors to human culture.

Although there is much to recommend this account, it depends exclusively on the role of adult–child collaborations. Nowhere are peer collaborations discussed. In our lab, we have studied early peer collaboration on tasks that require sharing a simple goal, and we find little evidence of either collaborative understanding or motivation to collaborate with peers until the close of the second year of life or well into the third year of life (Brownell & Carriger 1990, 1991; Brownell et al. 2003). Others have likewise suggested that collaborative peer play emerges toward the end of the second year of life (Asendorpf & Baudonniere 1993; Eckerman & Whitehead 1999; Eckerman et al. 1989). Only in the third year does cooperative play and communication with peers explicitly take into account the peer's actions, desires, and intentions (Ashley & Tomasello 1998; Smiley 2001).

These differences in development are not trivial. Such evidence does not call into question the assertion of Tomasello et al. that cultural cognition depends on shared intentionality, a point with which we fundamentally agree. But it does raise potential alternative developmental sequences and pathways, which in turn may introduce new explanatory demands and the possibility of other mechanisms. In particular, it suggests that shared intentionality may itself develop.

On the whole, infants and young toddlers do not appear particularly interested in social exchange with agemates, in contrast to their interest in collaborating socially with adults or even older siblings (Dunn 1988). Among 12-month-olds, familiar peers engage in simple social exchanges, such as looking and vocalizing to one another, less than once per hour. This increases over the second year to about once per five minutes at 24 months (Eckerman & Peterman 2001). Cooperative play with peers emerges between 20 and 24 months (Eckerman & Whitehead 1999; Eckerman et al. 1989; Howes 1988), and increases markedly between 24 and 28 months of age (Eckerman et al. 1989). Thus, the motivation to share intentions does not apply equally to all other persons early in development. One possibility for such a motivational difference is the developmental preeminence of attachment relationships during infancy (Brownell & Hazen 1999). Perhaps, in fact, it is their attachment relationships that make social engagement emotionally rewarding for infants and that first motivate them to share their emotions, desires and intentions.

Not only is children's interest in peer collaboration relatively late developing, but their ability to represent the peer's goals, in-

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tentions, and desires may also be relatively late to develop. On gamelike cooperation tasks, 12-month-olds cannot coordinate their behavior with one another to achieve a goal; 18-month-olds do so only serendipitously; 24- to 30-month-olds can do so once they have accidentally discovered the relation between their activity, the peer's activity, and the outcome (Brownell & Carriger 1990). When 24-month-olds' peer partners do something that interrupts or interferes with their joint activity, the children are stymied, rarely responding to their peer partner, and they do not try to influence the partner's behavior; instead, they continue their own individual activity. By 30 months, they monitor their partner's behavior and sometimes direct the partner verbally or gesturally (Brownell & Carriger 1991), and, by 36 months, children can plan ahead, exchange roles, and teach a cooperation game to another child (Ashley & Tomasello 1998). It appears that very young children do not recognize the relevance of their peers' behavior for their own efforts toward a common goal, nor the relevance of their behavior for their peers' attempts to achieve the goal; that is, they do not understand or represent the joint causal structure of their own and their peers' behavior in relation to the goal. This sort of understanding may depend on advances in complex causal reasoning independent of the ability or motivation to share activities, emotions, or experiences.

Another key developmental ingredient is developing self-awareness. As a 12-month-old, without a sense of who I am as an individual, a peer's approach is not *about* me; it is merely an interesting change in the surround. I may watch in interest, or even smile since I know that smiles get positive responses. As a more self-reflective 24-month-old, I know that a peer's behavior may be directed to and about me. I can infer, for example, that his approach means that he desires something of mine, and I can respond accordingly. At 36 months, we can negotiate our shared or conflicting desires, intentions, and goals. With progressive differentiation of reflective self-awareness and corresponding advances in reciprocal understanding of others as mental agents, a young child can increasingly share mental states with peers.

How does the child come to understand and share behavior, emotion, and intention with others? Perhaps it is an outgrowth of the child's emotional relationships with adults, combined with growth in causal reasoning and the differentiation of self- and other-understanding, and driven by the need to explain or predict others' behavior in an increasingly complex and unpredictable social world (Zerwas et al. 2004). Any or all of these components may be uniquely human; or perhaps it is their coalescence late in the second year of life that is unique to humans. Describing and explaining the similarities and differences in the course of shared intentionality with peers and adults will bring us closer to understanding the mechanisms underlying the genesis and development of collaboration.

Homo sapiens, a localized species

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Abstract: Tomasello et al. point up the mutual interdependency of the unique human capacity for intersubjectivity and the evolution and institutionalization of culture. Since both intersubjectivity and cultural cooperation require localized knowledge, *Homo sapiens* is highly reliant on such knowledge and in that sense is a highly localized species, requiring special means to surmount cultural misreadings and to achieve translocal, or global, interconnection.

The references listed at the end of the article by Tomasello et al. confirmed my first impression. Comparative studies of the emergence of intersubjectivity in *Homo sapiens* and his primate forebears began only yesterday. Of the 149 references cited by Tomasello et al., 81% have appeared since 1990, with most of the rest of them in the 1980s. The exception is Meredith Crawford's famous 1937 study showing how individual chimpanzees got one of their fellows to help haul in a food tray too heavy for either of them to manage alone, a paper shallowly read at the time as "proving" primate cooperativeness. Note, by the way, that few indeed of the great classics of evolutionary writing are cited in this bibliography – not Darwin and not LeGros Clark, to take only two examples.

The study of human evolution has taken a new and astonishing inward turn, far more concerned now with whether and how primates recognize (or fail to recognize) each other's intentions, or whether and how they manage (or fail to manage) to collaborate with each other in support of their respective intentions, or (in general) what evolutionary steps were required for *Homo sapiens* to have achieved the ability to recognize what their conspecifics have in mind prior to their acting it out. The emphasis is on the preconditions of human culture. The sweep and freshness of these new inquiries come through stunningly in this lucid and fair-minded overview.

Reading it leads me to a rather odd conjecture. May it not be the case that the unique result of human evolution – our newly acquired reliance upon conventionalized or institutionalized procedures for relating to each other and to the social world in general – that this is what makes ours the first and only "unspecies-like" species in the animal kingdom? I mean that in the sense that *unless* one human being has come to appreciate the "rules" of the cultural setting of those with whom he is interacting, he is unable to proceed collaboratively. In this sense, we as a species have become subdivided locally to a degree beyond any species that has ever existed. And this is not wholly by dint of being separated by different languages and their underlying perspectives, *pace* the Sapir-Whorf hypothesis.

The paradox, rather, is that *Homo sapiens* has become "localized" by having to depend upon learned, *culture*-specific modes of interacting. This local culture-specificity often *misguides* intercultural perceptions in a manner to create undesirable tensions and dangerous rivalry between local cultures. Localness has its costs: the tensions and misreadings it generates often deepen intercultural troubles at both the personal and institutional levels.

Our species has evolved in a most atypical way. We certainly did *not* evolve into some uniform steady-state species, as most speciation does. *Homo sapiens* has simply gone on changing, often massively, and in ways that confound the usual definition of species specificity. Once we develop a written language, for example, we begin leaving out of account even local intersubjective cues. And any monocultural technological innovation easily leads to misreadings of "other minds." When I and a medical colleague taught a priestly *marabou* how to use penicillin on the seriously ill in his Wolof Senegalese village, it was the success of his "renewed gaze" to Allah that most impressed the locals.

History, of course, further increases human localness, given its inevitably local perspectives. As devotees of the French *Annales* school put it, historians rightly search for the emergence of new *mentalités* produced by changing cultures (Furet 1985). They appreciate the power of the local.

As a species, then, we seem always to be *becoming* – differentiating, localizing, and even sublocalizing (as with class formation and the division of labor).

The universal-one-species dogma has, of course, been the dogma of colonialism in all its guises – that everybody everywhere *could* be the same if they were given the same cultural opportunities, the ones *we* have on offer. Beneath the compassionate surface of this ancient dogma lies the belief that *Homo sapiens* everywhere is capable of reading and appreciating what others in the human species have in mind – a dogma given a new lease on life by what's now called evolutionary psychology.

The enormous contribution of Tomasello et al. is to highlight the critical role of culture in support of human intersubjectivity and to demonstrate how this is made possible by our uniquely hu-

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man capabilities. It is this that leads me to emphasize the localness of intersubjectivity, for culture is always local.

I read their account as suggesting that *Homo sapiens* does not fit the usual definition of a species. By dint of our human dependence on cultural conventions, we have developed a degree of localness (or subspeciation, if one wants to be conciliatory with the past) that is unknown in any other species on the face of the earth.

Our bent toward "misreading" others in other cultures in the light of our local standards has led to distinctive, often lethal, intercultural scrappiness. Ironically, we as a species seem to be capable of the closest, most sensitive forms of intersubjectivity locally while, at the same time, remaining prone to gross intercultural misreadings where the intentions of others are concerned. And our local genius for devising ever-new procedures for using and expressing our minds often has the effect of further *sub*localizing us – as in the forming of social classes or by the creation of a castelike division of labor.

Yet, despite our genius for intersubjectivity and its cultivation, despite the localness of "subspeciation," *Homo sapiens* has also managed to create an ever-widening world of creative opportunities which, though it generates a chillingly greater killing rate than may be sustainable, would never have been imaginable by our ancestors.

Our localness, in a word, virtually disqualifies us as a species in the classical sense. We would do well to bear this in mind in considering the implications of the research reported in the brilliant account offered by Tomasello et al., for localness is now in ever-increasing tension with the universality that we aspire to in globalization.

Why do individuals with autism lack the motivation or capacity to share intentions?

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Abstract: Tomasello et al. highlight how in combination cognitive impairments and affective impairments help explain why individuals with autism do not enter fully into human culture. We query whether the motivational component is a later development in human ontogeny and whether the cognitive level of intention reading is intact in autism. A key question is what neuropsychological impairments underlie this cognitive–affective impairment.

Tomasello et al. do the field a great service by highlighting how *in combination* cognitive (or representational) impairments *and* affective (a motivation or capacity to share attention) impairments help explain why individuals with autism do not enter fully into human culture. It is important to emphasize that the developmental and behavioral impairments shown by individuals with autism cannot be explained by cognitive deficits alone (whether in theory of mind, executive function, central coherence or other cognitive processes [for a review, see Burack et al., 2001]). As recognized by the authors, this is a view long championed by some commentators, most notably Hobson (1993, 2002), and rings true to Kanner's (1943) original description of children with "inborn autistic disturbances of affective contact."

Do the authors mean to suggest that the motivational affective component is a *later-developing* component (than understanding the basics of intentional action) of the system in human ontogeny? This seems unlikely because, from the outset in human development, cognitive and affective development are intertwined. For example, studies that have adopted detailed analysis of infant–adult (usually caregiver) interactions have demonstrated that infants are sensitive to and engage in back-and-forth "protoconversations" from as young as 2 months of age (Bateson 1975; Trevarthen 1974). These involve rhythmic attunement of mother and infant vocalizations with the mother protracting, amplifying and enhancing versions of the infant's sounds (Papousek 1989; Trevarthen et al. 1999). Such exchanges are affect laden; the vocal protoconversation is accompanied by other sympathetic reactions that are non-imitative such as smiles, mutual gaze, hand gestures and affective vocal expressions. Stern (1985) has called these "supportive emotional colored attunements." Clinically some parents of children with autism report that their babies were unresponsive in the first months of life (Wing 1996), suggesting that they might not be as motivated as other children to enter into such exchanges.

Are the authors sure that evidence that the cognitive level of intention reading is intact in autism secure? They cite two studies that have found that children with autism produce the target action following a "failed demonstration" in Meltzoff's (1995) behavioral re-enactment task (Aldridge et al. 2000; Carpenter et al. 2001). Previously we have argued that non-social learning processes including stimulus enhancement and emulation learning might account for such findings (Charman & Huang 2002; Huang et al. 2002). In an earlier study, we used one such task with toddlers with autism, and only 3 of 20 children with autism spectrum disorders copied the experimenter's action of lighting the box by bending down with their head (Charman et al. 1997). It would also be of interest to know the emotional reaction of the children with autism tested by Carpenter et al. (2001). Whilst we are told that "they looked to the light in anticipation, seemingly indicating their appreciation of the goal-directed nature of this action," we do not know whether the children with autism responded as many typical children do with gales of laughter, smiles, and quizzical looks at the experimenter. Footnote 4 also indicates that chimpanzees produce the target action following failed attempt demonstrations in the behavioral re-enactment procedure (and indeed at baseline presentation when no action is demonstrated). This response is presumably via non-social learning processes such as those already mentioned as well as natural object affordances. This is not to argue that intention reading is not involved in imitation situations. Rather it is intended to emphasize that in typical development it is there in combination with non-social learning and with affective engagement (try playing imitation games with toddlers and keeping a straight face). It might not be correct to think of one part of this system as intact in children with autism and another impaired. Clearly, the system as a whole does not function as it should, and this might involve both the cognitive and the affective components of the system (Tager-Flusberg 2001).

A key area of investigation in autism is to identify what neuropsychological impairments underlie this affective impairment, whether the deficit is best understood in terms of motivation or capacity, and to determine which brain systems subserve these impairments and how their function might be disrupted. A useful model of the components that such cognitive-affective capacities require is that of a social information-processing network (SIPN [Nelson et al., 2005]). SIPN involves the *detection* of a stimulus as social; an *affective* engagement with the social stimulus; and a *cognitive-regulatory* component (akin to theory of mind) that helps decide and enact a response to the stimulus. Each node is associated with particular neural systems, and there is converging evidence that these systems are structurally and functionally impaired in individuals with autism (Baron-Cohen et al. 2000; Frith & Frith 2003; Nelson et al., 2005).

Interestingly, there is convergent evidence from such research that the cognitive and the affective components of the system might be more intertwined that we once expected. For example, Schultz et al. (2003) found that the fusiform face area was activated during a social attribution (theory of mind) task. Hypoactivation of this region in individuals with autism whilst processing faces is the best replicated functional imaging finding in the field (Schultz et al. 2000, 2003). Klin et al. (2003) remind us that within an "enactive mind" framework cognitive development is in part dependent on what is seen as salient in the environment. Several models of de-

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velopmental impairments in autism emphasize that for individuals with autism there appears to be a reduced salience of social signals and social rewards (Dawson et al. 2002b; Mundy et al. 2003). This might reflect either a reduced *capacity* to recognize, identify, think, and respond to social signals; alternatively, it might explain how over development individuals with autism have a reduced *motivation* to respond to social signals they fail to find rewarding. As Tomasello et al. highlight, the inevitable consequence of such impairments is an inability to enter fully into human culture.

Toward a construction-based account of shared intentions in social cognition

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Abstract: This commentary analyzes the target article to determine whether shared-intention development could be implemented and tested in robotic systems. The analysis indicates that such an implementation should be feasible and will likely rely on a construction-based approach similar to that employed in the construction grammar framework.

The theoretical framework presented by Tomasello et al. is of particular interest for researchers in the domain of cognitive robotics, whose goals include the development of artificial robotic systems that are endowed with the social cognition capabilities described in the target article. I analyze the article to begin to formalize the internal representations and operations on those representations (e.g. transformations, combinations) in order to determine how they might provide the basis for implementation of an artificial system that could perform like young infants in the development and use of dialogic cognitive representations. Interestingly, one of the outcomes of this analysis is the suggestion that the notion of *construction* as a structured mapping in the construction grammar framework for language can be generalized or extended to the domain of social cognition.

It is assumed that the child comes to the task with a perceptual capability that provides a set of basic representations and operations on those representations. Thus, the child can (1) perceive physical states of objects, (2) perceive physical actions performed by agents that can change the states of these objects, and (3) distinguish between self and other in this context. Likewise the child can (4) perceive the emotional responses of others. In addition, we will assume (5) some form of statistical learning mechanism (e.g., see Saffran et al. 1996) that forms representations that bind together co-occurring and successive events and that can represent variables that can be instantiated in these representations (Dominey & Ramus 2000; Marcus et al. 1999).

Given this machinery, we can consider the ontogenetic development of a form of action construction in which, after repeatedly performing an action (e.g., picking up a block and throwing it), the child will begin to form a representation of the form [initial state, action, and final state] instantiated as [block in hand, throw block, and block on floor]. Although the block may start and end in different locations, and the throwing trajectory may be different, the invariant sequence will be repeated enough times to allow statistical learning to take place, linking the initial state, action, and final state into a coherent cognitive object: an action construction. Interestingly, an analogy with grammatical constructions and the transition in language from fixed holoconstruction to single-argument or verb-island constructions appears here. The throw-block construction is like a fixed holophrase in language: it has a highly limited and specific scope of application. As the child comes to throw different objects, the throw-block construction can become slightly more abstract as the throw(X) construction [in hand(X), throw(X), on floor(X)], analogous to the verb-island constructions in language in a progressive development of more abstract constructions. This introduction of variables and their manipulation could rely on the learning mechanism demonstrated in infants by Marcus et al. (1999) and simulated by Dominey and Ramus (2000) and Dominey et al. (1998).

The resulting relation between initial state, action, and final state enables the development of the intentional construction based on the action construction. In the intentional construction, the final state is the goal, and the initial state and action constitute the intention associated with realizing the goal. These intentional constructions will contribute to the "knowledge, skills" component of Figures 1 and 2 of the target article, and when a goal arises, the construction inventory can be searched to find the appropriate construction and extract the corresponding intention.

We can now consider how this framework might extend to the formation of dialogic cognitive representations. Consider a scenario in which a child is seated on the floor and is reaching for, but failing to reach, a toy block. An adult arrives, sees that the child wants the block but cannot reach it, and so pushes the block to within the child's reach. The child then successfully reaches for and grasps the block, and throws it out of its own reach, and the scenario repeats in a "throw the block" game between the child and the adult enough times so that statistical learning can take place.

In this scenario, the child has a goal of grasping and throwing the block. It has already learned an intentional construction [initial state, action, and final goal-state] of the form [within reach(X), grasp(X), and in hand(X)], and so knows [by chaining the throw(X) and grasp(X) constructions from the construction inventory] that in order to throw the block it must first grasp it. The child attempts to grasp the block but fails because it is out of reach. This creates a subgoal (getting the block within reach) for which there is currently no appropriate action. However, when the adult moves the toy within reach, it becomes graspable, and the intentional construction plan (grasping and throwing the block) can then be executed. Sufficient repetition of the "game" will enable learning mechanisms to bind states and actions together. Interestingly, however, the intentional representation will include actions by both participants. In particular, the subgoal of getting the toy back into reach after it has been thrown is assigned to the adult. More generally, intentional constructions that form part of an intentional plan can be assigned to different participants in a distributed manner, with each participant maintaining his/her representation of the complete distributed plan: the joint intention. Thus, we see mechanistically how joint intentions will be formed in both participants through their participation and observation of the unrolling of actions in a goal-directed manner, with the goal and the execution of the actions shared by the two participants.

The resulting joint intentional representation is a precursor of more articulated dialogic cognitive representations, but still provides a basis for quite interesting interaction. For example, based on the notion of *help* as intervention in an intentional plan by a collaborator (e.g., the adult in the foregoing scenario), the child can learn to request help and to help others under appropriate conditions. Likewise, the notion of *game* naturally develops from this type of representation. This provides both a powerful analytical tool for human behavior and an important step toward the specification of social cognition mechanisms for cognitive robots (Dominey & Boucher 2005).

The current preliminary analysis suggests that the characterization of the mechanisms for shared intentions in the target article is of sufficient detail to enable their implementation in a formalized manner that can eventually be used and tested in the context of artificial systems that interact with humans and/or other systems. In addition, it appears that the functional/computational mechanisms supporting these capabilities can be encompassed within the structure-mapping framework that has been of particular use in the construction grammar approach to natural language (see Dominey 2004; Dominey & Boucher 2005). Indeed, this is not surprising, because language and social cognition are highly interrelated.

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Symbolic behavior and perspective-taking are forms of derived relational responding and can be learned

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Abstract: Numerous questions remain unanswered concerning the functional determinants of symbolic behavior and perspective-taking, particularly regarding the capabilities of children with autism. An alternative approach that considers these behaviors to be forms of derived relational responding allows for the design of functional intervention programs to establish such repertoires in individuals for whom they are absent.

Tomasello et al. argue that children with autism exhibit deficits in shared intentionality and that the use of symbols is considered to be a particular problem area for this population. However, they fail to elaborate on the extent to which these deficits might be ameliorated, and what implications this might have for their account. Many questions remain unanswered concerning the functional determinants of these behaviors and how they can be added to an individual's behavioral repertoire once they are found to be lacking. We will address these issues within the context of modern behavioral approaches to symbolic behavior and perspective-taking that consider these behaviors to be forms of derived relational responding.

Conflicting definitions of symbols abound in the developmental literature, yet research conducted over the past 30 years within the behavior-analytic tradition on derived relational responding offers a functional account of the kinds of symbolic behaviors that constitute the very core of human language and cognition (Hayes & Hayes 1992; Hayes et al., 2001; Horne & Lowe 1996). The research has shown a remarkable propensity, given appropriate training conditions, for children with autism and other developmental disorders to produce novel behavior indicative of the efficient use of symbols. Derived relational responding, which at the moment appears to be a uniquely human ability (see Dymond et al., 2003), may in fact be a fundamental process involved in language because of its similarity with the bidirectionality of word-referent relations. In the course of early language training, children learn perhaps one of the most important forms of derived relational responding, which is to name and point to objects and events and to derive relations among these events with increasing complexity as the child develops (Lipkens et al., 1993). For instance, on hearing the spoken word "car," pointing to an actual toy car may be taught. This training episode may be described as "hear name, see and point to object." Next, when presented with a picture of a toy car, a child may be taught to point to the actual toy car ("see picture, point to object"). Following such a training history, emergent relations among the stimuli can then be tested; that is, a child may produce the spoken word "car" and point to a picture when shown the actual toy car (called symmetry or mutual entailment), without further training. Similarly, a child may point to a picture on hearing the spoken word, and vice versa (called equivalence or combinatorial entailment), all without additional training.

These derived performances are, we would argue, symbolic because the child spontaneously derives relations among all stimuli after learning only a subset of baseline relations. Children with autism, including those lacking vocal naming abilities, can derive stimulus relations such as equivalence and exclusion but may occasionally require specialized instructional training protocols before they do so (see Carr 2003; Carr et al., 2000; Eikeseth & Smith 1992; O'Donnell & Saunders 2003; Stromer et al., 1996; Wilkinson & McIlvane 2001). Thus, there are no grounds for claiming that symbolic behavior, or derived relational responding, is either problematic or beyond the behavioral capabilities of children with autism and other developmental disorders. Furthermore, an approach that emphasizes the functional components of symbolic behavior also permits inclusion of symbolic responses other than vocal responses (e.g., manual signing) in the communicative repertoires of children with autism. Reference to such alternative repertoires is notably absent from Tomasello et al.'s account.

Perspective-taking skills, when considered to be a form of derived relational responding, may emerge in a similar manner following a history of explicit reinforcement for answering questions that require the child to shift perspectives between *I–You*, *Now–Then*, and *Here–There*, such as "What am I doing here?" and "What are you doing now?" (Barnes-Holmes et al., 2001; Dymond & Barnes 1994, 1997; McHugh et al., 2004). Although the form of these questions may often be identical, the physical environment is altered each time a question is asked or answered. What remains constant across these events are the relational properties of the deictic terms. Across the course of development and throughout daily discourse, a child learns that *I* is always from this perspective *here*, but not from another's perspective *there*. In this way, the perspective-taking functions of answering questions may be present even if the actual deictic terms are absent as alternative words serve the same contextual function and enable a child to learn to respond appropriately as if the actual terms had been used. We contend that it is contextually controlled ontogenetic histories such as these that Tomasello et al. are referring to when they mention the contribution of "specific experiences" and "forms of perspective-shifting discourse" on the emergence of joint attentional activities.

Approaching perspective-taking as a form of derived relational responding allows for the design of intervention programs to establish such skills in individuals for whom they are absent. Directly training perspective-taking skills of varying complexity across multiple exemplars and then testing for generalized responding with novel question sets is, in our view, a more pragmatically useful approach than "theory-of-mind" alternatives that attempt to teach children with autism about informational states. While considerable applied research remains to be done, functional intervention-based approaches have already been shown to be effective in overcoming joint attention deficits in autism (see Dube et al., 2004; Jones & Carr 2004; Whalen & Schriebman 2003). We contend that approaches such as these will be of more practical use than accounts that either fail to specify the conditions under which deficits can be overcome or completely disregard this as a pragmatic goal at all.

ACKNOWLEDGMENTS
We are grateful to Rob Whelan, Ruth Anne Rehfeldt, and Eric Fox for helpful comments.

Interaction synchrony and neural circuits contribute to shared intentionality

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Abstract: In the dyadic and triadic sharing of emotions, intentions, and behaviors in families, interactive synchrony is important to the early life experiences that contribute to the development of cultural cognition. This synchrony likely depends on neurobiological circuits, currently under study with brain imaging, that involve attention, stress response, and memory.

If shared intentionality is the apex of evolutionary cognition, as suggested by Tomasello et al. interaction synchrony is among its

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central precursors. During the third month of life, human infants begin to partake in synchronous social interactions, a context in which infants learn to recognize and respond to the communicative intents of others, share emotions, take turns in a vocal exchange, match the partner's gaze directions and facial expressions, and respond to microshifts in attentive states and levels of social involvement (Feldman et al. 1999; Tronick 1989). These early face-to-face interactions between parents and infants are composed of microlevel behavioral units that follow dyad-specific rhythmic patterns, and infants at that stage can anticipate the partner's rhythms and coordinate their behavior accordingly. Although the centrality of face-to-face communication varies across societies, infants of all cultures become active partners in a matched social dialogue at around the same age (Richter 1995) – an experience uniquely human, as no other species sensitizes its young to such coordinated responsivity to facial social signals. Mothers and fathers synchronize with their infants to the same degree but use different modes of interpersonal synchrony – mothers by focusing on a rhythmic face-to-face exchange, and fathers by constructing chains of highly aroused play with an object focus (Feldman 2003). During that stage, infants can also meaningfully participate in triadic social interactions with their mothers and fathers. Three-month-old infants shift their social orientation between the parents during triadic play following the interacting parent switching his or her gaze from infant to spouse, and such capacity suggests an early awareness to a social signaling system between independent others (Feldman et al. 2003). At about 4 months of age, mothers begin to attribute intentionality to their infants' behaviors, thus creating the mental context for the emergence of the infant's intentional action (Feldman & Reznick 1996). Such close involvement with the social world – prior to the emergence of reaching and grasping that allow for a meaningful involvement with the world of objects – precedes the shared intentionality and the triadic infant-other-object relationships of the later part of the first year and suggest a biological preparedness provided by the early synchrony of affective states for the development of tool use, mind reading, symbolization, and creativity (Feldman & Greenbaum 1997).

The biological basis for the infant's capacity to partake in synchronous social dialogue is provided by the organization of physiological oscillators during the neonatal period, such as the biological clock and heart rhythms, and more organized sleep–wake cyclicity and heart-rate variability of the neonate predict a tighter synchronous match between mother and child at 3 months (Feldman, in press). Because of the infant's immature physiological regulation, the organization of biological processes such as sleep and wakefulness, thermoregulation, autonomic regulation, and activity level depend on the external regulation afforded by the mother's proximity, contact, and social stimuli (Hofer 1995), and this dependence sensitizes the infant to minor alterations in maternal closeness and communicative signals. While engaging the infant in coordinated interpersonal timing, mothers entrain the infant's biological rhythms and transform the predictable periodic rhythms of physiological oscillators into a stochastic–probabilistic process that is open to the external signals of the social and nonsocial environment and can incorporate the changing states and emerging intents of the interacting partner into the stream of behavior (Fogel 1993; Trevarthen 1979). Parent–infant synchrony in the first months of life has a formative role in brain maturation and was found to predict children's self-regulation, symbolic play, cognitive skills, and behavior adaptation in later childhood (Feldman & Eidelman 2004; Feldman et al. 1996, 1999). Interaction synchrony is also sensitive to risk conditions stemming from both parent and child, and the degree of synchrony tends to decrease in cases of maternal depression, prematurity, or multiple birth (Field 1994; Lester et al. 1985). Thus, the experience of synchrony provides a link between brainstem-mediated homeostatic functions, to limbic structures involved in the identification and sharing of emotions, to cortical systems responsible for the regulation of behavior and the sharing of mental states.

The brain basis of the developing parent-infant bond may be approached with functional neuroimaging. Noninvasive dense-array measurement of electroencephalographic baby brain signals during social situations may soon be possible. The use of functional magnetic resonance imaging to study parental brain responses to emotionally charged baby stimuli was pioneered by Lorberbaum et al. (2002), who used standard baby cries as stimuli for parents. Thalamocingulate circuits as well as medial and orbitofrontal cortices, midbrain, hypothalamus, striatum, and septal regions were selectively more active in response to baby cry. Building on this work, Swain et al. (2003) have been studying primiparous and multiparous mothers and fathers at multiple time points using own baby cry and picture stimuli with the hypothesis that early parenting brain responses may share activations with certain psychopathologies such as obsessive–compulsive disorder (Leckman et al. 2004). Brain regions relatively activated by own versus other baby stimuli include midbrain, thalamus, basal ganglia, amygdala, insula, and cingulate. In addition, parental responses appear to shift over the first 3 to 4 months postpartum as the relationship develops (Swain et al. 2004). Several other groups are working in this area, using different experimental paradigms and populations (Bartels and Zeki 2004; Leibenluft et al. 2004; Nitschke et al. 2004; Ranote et al. 2004; Seifritz et al. 2003; Swain et al. 2003); and this approach promises to reveal brain structures necessary for parent-infant attachment, including behavioral synchrony and shared intentionality. Thus far, emotion-control centers are found to be activated by baby signals across investigators – areas in agreement with the animal literature on pup-directed maternal behavior (Leckman and Herman 2002; Numan and Sheehan 1997). Combinations of well-controlled stimuli, sensitive psychometric data, and ethologically valid stimuli may clarify the specific importance of these brain circuits to mediate normal parental behavior in humans and lay the foundation for future studies of baby brain development and abnormalities of parent-infant bonding related to such conditions as postpartum depression and infant psychopathology.

What is internalised? Dialogic cognitive representations and the mediated mind

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Abstract: Two aspects of Tomasello et al.'s account would benefit from further elaboration: (1) the construction of dialogic cognitive representations through social interaction, and (2) the cognitive consequences of operating with such representations. Vygotskian ideas on internalisation and verbal mediation may help us better to understand how dialogic cognitive representations can transform human cognition.

Tomasello et al. argue compellingly for the importance of shared intentionality for individuals' ability to engage in species-unique forms of cognition. On their account, the main developmental outcome of the intertwining of intentional agent understanding with motivated intention-sharing is a form of cognitive representation rich enough to incorporate both first-person and third-person perspectives on an episode of social interaction. Phylogenetically and ontogenetically, such dialogic cognitive representations underlie humans' capacity to engage with others as thinkers. This account, which sees the fundamentals of cultural cognition as being established at around 14 months, has the drawback of attributing considerable cognitive sophistication to quite young infants, while at the same time appearing to leave little scope for later development to build upon these prelinguistic forms of social–cognitive understanding. Tomasello et al.'s "small difference that made a big difference" (sect. 6, para. 2) is therefore probably too small. Two spe-

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cific aspects of their account would benefit from further elaboration: (1) the ontogenetic process through which dialogic cognitive representations are constructed, and (2) the cognitive implications of the developing ability to operate with such representations.

With regard to the first of these issues, Tomasello et al. are upfront about the fact that they have no satisfactory developmental account of the creation of dialogic cognitive representations. Along with others who have addressed related questions (e.g., see Carpendale & Lewis 2004; Symons 2004), they appeal to Vygotsky's notion of internalisation to explain how dialogic representations of others' intentional relations become transferred to the intrapsychological plane (Vygotsky 1987). The problem is that, if you are going to have internalisation, you have to have something that is internalised. For Vygotsky, what is internalised is semiotically (primarily linguistically) mediated interaction with others. For example, the Vygotskian account of the development of inner speech sees it as beginning with the gradual internalisation of dialogues with others, developing through the intermediate stage of private speech (incorporating dialogic exchanges with self), and ultimately "going underground" to form inner speech. Crucially, this process entails the internalisation of the multiple perspectives represented in the dialogue, with their triadic intentional relations remaining intact (Fernyhough 1996, 2004). As a number of authors have noted (e.g., see Bakhtin 1986; Hermans 1996), semiotic systems such as natural language are uniquely equipped to make manifest this simultaneous multiplicity of perspectives.

A more whole-hearted embracing of Vygotskian internalisation would thus allow Tomasello et al.'s dialogic cognitive representations to accommodate the intentional relations of the individuals with whom the child is in collaboration, or to "encompass simultaneously both first-person and third-person perspectives" (note 9). What they might have to let go of, however, is the idea that language is entirely derivative of these important social–cognitive accomplishments. Natural-language discourse, as a special case of semiotically mediated activity, does not have to wait until shared intentionality is fully established. Rather, it can get started during the (ontogenetically earlier) stages of dyadic and triadic engagement, and can thereby play a part in the transition to collaborative engagement, and the full, dialogic, reciprocal intention-sharing that Tomasello et al. have shown to be so important. To put it another way, the cognitive benefits of using words as tools for thought – in this case, language's ability to represent the multiple perspectives manifested in dialogue – might be a way of offsetting the daunting cognitive challenges that participation in collaborative engagement (especially as early as 14 months) must present. Thus, language is indeed more than "a set of coordination devices for directing the attention of others" (sect. 6, para. 3); it is a psychological tool (Vygotsky 1978) which comes to mediate children's mental lives and reduce the processing demands of operating with complex representations (Clark 1998).

With regard to the second issue, Tomasello et al. appear slightly to undersell the implications of being able to operate with dialogic cognitive representations. If, as I suspect they would want to claim, possession of such representations buys the individual the ability to reason in reflexive, multiperspectival internal dialogues, then the implications for cognition are profound (and would certainly go beyond the reference to "social norms and their constitutive conventional practices" [sect. 5.2, para. 11]). Rather, internal dialogue endows the individual with a way of thinking that is flexible, open-ended, and capable of encompassing different perspectives on reality at the same time (Fernyhough 1996). For example, false-belief understanding (which typically requires the simultaneous accommodation of one protagonist's informed perspective alongside another protagonist's naïve perspective) can be construed as a product of dialogic thinking (Fernyhough 2004). The authors imply that a fully fledged theory of mind must be developmentally dependent upon the ability to operate with dialogic cognitive representations, but they do not have much to say about the other correlates and sequelae of this developmental achievement. For example, one consequence of the difficulties faced by individuals with autism in sharing intentional states with others may be the cognitive inflexibility that characterises the disorder, and which on this view would stem from an inability to engage in mediated internal dialogue (Fernyhough 1996). In addition, it would be interesting to consider how individual differences in the motivation to share intentions, on the part of both infants and the adults who provide much of their social context, might affect children's later development. The authors note that there is currently little data on such individual differences in infancy, and it will be interesting to see how future research addresses this gap. As far as adults are concerned, the construct of mind-mindedness (Meins 1997; Meins et al. 2003) can be construed as involving the willingness, as well as the capacity, to share intentions with others. Presumably Tomasello et al.'s account will have something to say about how individual differences in caregivers' intention-sharing motivation will affect infants' developing capacities for collaborative engagement and the cultural–cognitive achievements that flow from that.

Animal cognition meets evo-devo

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Abstract: Sound comparative psychology and modern evolutionary and developmental biology (often called evo-devo) emphasize powerful effects of developmental conditions on the expression of genetic endowment. Both demand that evolutionary theorists recognize these effects. Instead, Tomasello et al. compares studies of normal human children with studies of chimpanzees reared and maintained in cognitively deprived conditions, while ignoring studies of chimpanzees in cognitively appropriate environments.

Karl Marbe, distinguished German experimental cognitive psychologist, studied Basso, a chimpanzee in the Frankfurt zoo, that solved arithmetic problems (Marbe 1917). Asked in German "How much is six plus four?" Basso selected a card bearing the number "10" as in Figure 1. Verifying that Basso was usually correct, Marbe interviewed the zookeeper and trainer who drilled Basso on simple problems as one might drill a small schoolchild, but without believing that Basso could do arithmetic. He believed,

Figure 1 (Gardner). Array for testing chimpanzee Basso (Marbe 1917) as in infant tests (e.g., Tomasello & Haberl 2003).

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instead, that Basso read his mind. Marbe tested this hypothesis by asking the trainer to give Basso a series of arithmetic problems and think wrong answers. The result was decisive. Basso repeatedly gave the answer that his trainer was thinking, regardless of the correct answer in arithmetic. He succeeded at mind reading where he failed at arithmetic.

Further tests showed that Basso selected the card that his trainer looked at. The trainer himself was unaware that he was gazing at the correct card or giving any visible hints whatsoever. Earlier, Pfungst (1965) showed that Hans, a German horse, solved arithmetic problems and also spelled out German words by following the gaze of human interlocutors who were also unaware that they were hinting. Soon, experimental procedures that control for inadvertent hints became standard in comparative psychology (B. Gardner & Gardner 1989a; Warden & Warner 1928).

Warden and Warner's dog Fellow, Pfungst's horse Hans, and Marbe's chimpanzee Basso developed and lived in enriched conditions that fostered cognitive and social development. Respected authorities once taught that developmental environment was insignificant compared with species specific genetic endowment:

> Maturational factors . . . are sufficient to ensure the early development of typical . . . behavior as long as nutrition, shelter, space for practice, and perhaps a minimum of kindness from mother substitutes for infants not left with their mothers are provided. (Riesen & Kinder 1952, p. 173)

Mounting evidence revealed dramatic contrasts between individual and institutional child rearing that contradicted traditional doctrine. In institutions, Dennis (1960) and Hunt et al. (1976), for example, reported profound retardation, especially in institutions with a high infant-to-caretaker ratio. Some infants could neither sit alone nor creep at age 1, and many could not walk at age 2. Experimentally lowering infant-to-caretaker ratio produced dramatic effects. Mean age for sitting alone dropped from 39 weeks to 27 weeks and, for standing and cruising while holding onto the crib edge, from 69 weeks down to 41 (Hunt et al. 1976, pp. 207–8).

The human pattern of institutional deficit reappears in lab-reared chimpanzees. Riesen and Kinder (1952) recorded age of onset of motor milestones for 14 infant chimpanzees reared at Yerkes Laboratories (Orange Park, FL) with the items of Gesell and Thompson's (1929) test for human infants. They found a parallel pattern of development with laboratory infants somewhat ahead of human infants. B. Gardner and Gardner (1989b, Table 3) compares cage-reared chimpanzees in Riesen and Kinder (1952) with wild chimpanzees reared by their own mothers and observed by Goodall (1967) and Plooij (1984). Just as human infants reared by their own mothers are ahead of human infants reared in institutions, so chimpanzee infants reared in the wild are well ahead of chimpanzee infants reared in cages; for example, sit when propped at 10 weeks for wild and 19 weeks for caged infants; and stand alone at 12 weeks for wild and 39 weeks for caged infants.

Comparisons between human children and other animals such as those cited in Tomasello et al. continue to overlook effects of behavioral and social environment. Such experiments compare chimpanzees that live in cages – lucky if they have a rubber tire to play with or a rope to swing from – with human children that live in the rich environment of suburban homes. In these studies, developmental age is number of years that an animal has lived under deprived conditions. Most modern psychologists would expect human children to lose rather than develop intelligence under comparable conditions. Indeed, older captives often score lower than younger captives on cognitive tasks (e.g., Povinelli et al. 1993; Tomasello et al. 1987). Studies of caged chimpanzees led Hare et al. (2002) to conclude, "Dogs are more skillful than great apes at a number of tasks in which they must read human communicative signals indicating the location of hidden food." In a report by Povinelli and Eddy (1996), chimpanzees reared and maintained under cognitively and socially deprived conditions failed to discriminate between an ordinary human being and one with a bucket over his head, or even to learn this discrimination after repeated trials.

Credible comparisons depend on comparable conditions. In cross-fostering, parents of one genetic stock rear offspring of a different genetic stock (R. Gardner & Gardner 1989; Goodenough et al. 1993; Stamps 2003). This well-established method controls for and measures interaction between genetic evolution and developmental environment (evo-devo) (Robert 2004; Wagner et al. 2000). Cross-fostering began for chimpanzee Washoe after she was 9 or 10 months old, whereas Moja, Pili, Tatu, and Dar were cross-fostered from birth. B. Gardner and Gardner (1989b) compared the age of onset of 50 early postural, locomotor, manipulative, perceptual, and social behaviors for Moja, Pili, Tatu, and Dar with norms established for human infants by Dennis and Dennis (1937), Shirley (1931/1933), and Cohen and Gross (1979). The cross-fosterlings were ahead of human infants on some items such as fixating objects and playing with own hands, but the sequence of development was highly correlated, rho = 0.77 (B. Gardner & Gardner 1989b, pp. 439–41, Tables 1 and 2). Table 3 of B. Gardner and Gardner (1989b) compares cage-reared, wild-reared, and cross-fostered chimpanzees on overlapping items. On these milestones of development, cross-fostered chimpanzees are slightly ahead of wild chimpanzees reared by their own mothers, whereas both wild and cross-fostered infants are dramatically advanced compared to cage-reared infants. With respect to these milestones of the first year, cross-fostering provided a favorable developmental environment.

More advanced development under cross-fostering enables more advanced comparisons with studies of human children. Size of vocabulary, appropriate use of sentence constituents, number of utterances, proportion of phrases, and inflection, all grew robustly throughout 5 years of cross-fostering, but more slowly than in human children. Growth was patterned growth and patterns were consistent across chimpanzees. Wherever there are comparable measurements, patterns of growth for cross-fostered chimpanzees paralleled in detail characteristic patterns reported for human infants (B. Gardner & Gardner 1998). In studies by Bodamer and Gardner (2002) and Jensvold and Gardner (2000), conversational probes evoked conversationally contingent rejoinders from cross-fosterlings who used conversational devices to maintain topics of conversation the way human adults and human children use these devices (Brinton & Fujiki 1984; Ciocci & Baran 1998; Garvey 1979; Halliday & Hansen 1976; Wilcox & Webster 1980). Contingencies were comparable to contingences reported for human children (Bloom 1991, 1993) and more comparable to older children than to younger children.

Modern evolutionary and developmental biology (evo-devo) demands that evolutionary theorists recognize the powerful contribution of developmental conditions. Tomasello et al. need to face this challenge.

What are the consequences of understanding the complex goal-directed actions of others?

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Abstract: Four issues that build on the ideas offered by Tomasello et al. are discussed: the developmental course of shared intentionality and its relation to other developing abilities and experiences, and the conceptualization of three key features of the process: motivation, plans and the development of planning, and culture.

Humans have extraordinary social and cognitive capabilities. These capabilities develop side by side, bootstrapping one another over the course of infancy and childhood. As a result, children gain access to the ideas and behaviors of others, and they come to under-

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stand much about the social and psychological world. To study the basic psychological processes that are involved, developmentalists have directed their attention toward infants and how they come to understand the self and other people as intentional agents. Tomasello et al. use this research to present a provocative and informative view as to how these early behaviors enable children to develop skills that immerse them psychologically in culture. This commentary concentrates on four aspects of the proposal: the developmental course outlined and three key conceptual features – motivation, planning, and culture – that are used to support this view.

Developmental course. A full accounting of development needs to include, in some integrated way, the social, emotional, cognitive, and physiological aspects of growth. Although such integration is a tall order, it is nonetheless critical for understanding and explaining development. Such integration is lacking in the conceptualization offered by Tomasello et al., though the potential to add this information exists in the model and would be a welcome next step. However, at present there is scant attention to emotional and physiological processes, either as concomitant factors or about how they may regulate the social and cognitive transactions involved in shared intentionality. These contributions undoubtedly play a critical role in this process, and much extant research could fill in some of the pieces. Another, more troubling, limitation for describing development crops up when one thinks about this process beyond the first few years of life. There is simply too little offered here to know how shared intentionality changes in its form and contribution from infancy to childhood as new skills at remembering, problem solving, planning, and self-regulation appear.

Motivation. Tomasello et al. use the concept of motivation as the underlying force that propels the child to share intentions with others. Unfortunately, a definition of motivation is not provided, which presents serious problems for a psychological explanation that is primarily concerned with how children learn complex information voluntarily. Is the motive a physiological process, such as an arousal state, that primes the child for learning in social context? Or is it related to survival, which may be more in keeping with the evolutionary view presented? Or is there some other type of need involved, perhaps reflecting psychological or social constructs like interest, curiosity, or affiliation? Without description of the underlying motive and how it may organize the timing and trajectory of this process, it is difficult to understand the role that shared intentions play in psychological development or explain variation in the process.

Plans and the development of planning. To provide a social explanation for learning complex behavioral streams, Tomasello et al. introduce the notion of shared intentionality in which children attend to sequences of goal-directed actions or the plans of other people. There is long-standing interest in psychology in plans and the development of planning (e.g., see Friedman et al. 1987; Miller et al. 1960). Linking early understanding of intentions to this capability is interesting and advances ideas that appeared in early research in this area (Bruner 1981). To develop these ideas further, Tomasello et al. need a clearer definition of plans and planning – one that describes how plans emerge from shared intentionality and how these relate to other future-oriented processes in infancy (Haith et al. 1994) and to the development of planning in childhood and adolescence. Articulating these connections may also help answer questions about the developmental course of shared intentionality and possibly link children's understanding of shared intentions with the ability to use plans that are already established in a culture, such as those involved in rituals and routines.

Culture. Many of the activities important to a culture become routine practices, and children are often asked to participate in these practices, especially rituals, long before they can understand the meaning and intention of these behaviors. This observation begs several questions: Can children participate in cultural routines without understanding their intentions? If understanding of intentions is needed, how much is sufficient? And does participation without full understanding of intentions have consequences for development? Rogoff (2003) suggests some answers to these questions. She describes children's thinking as an emergent process as children gradually assume new and more responsible roles in culturally organized activities. For instance, a very young child may be seated on her mother's lap as the family eats dinner. Is the child participating in dinner, a culturally organized and intelligent action? Yes, to the degree that she is able. Is the child engaging in shared intentionality? Probably not initially, but eventually she will be. At what point in this process, then, does cognitive development and immersion into culture commence? It seems to me that the child is participating in culture from the outset of this experience, albeit in a limited way, and that this participation helps the child, over time, piece together ideas about the activity, including shared intentionality. What Rogoff's ideas suggest seems quite different from what Tomasello et al. describe. Surely the basic processes described by Tomasello et al. are part of the overall mix, but in and of themselves they do not explain the full scope of cognitive development in sociocultural context.

Finally, a view of cognitive development in sociocultural context needs to explain the psychological processes that underlie the historical coherence of culture. Along these lines, it seems far more obvious why a dependent infant would be motivated to seek information from conspecifics than why adults would want to create shared intentions with infants. To answer this question, a description of cognitive development in social and cultural context needs to include the vantage of the adult as well as the infant. Tomasello et al. focus on the infant. In contrast, a focus on the adult role requires more consideration of the socioemotional components of these transactions. Although there are cognitive aspects of the adult's activity – for example, adults need to learn how to care for and engage infants – the vital part from the adult's viewpoint has more to do with relationships than cognition. Stated differently, cognition develops in culture in the context of social relationships (Hinde 1989). These relationships entail powerful motivational forces, emotional connections, and sustained opportunities for children and adults to get to know one another as well as each other's peculiar and routine ways of behaving. An evolutionary explanation could undoubtedly be crafted that would include most, if not all, of these factors, but such a description would be far too distal to explain the types of questions psychologists have about individual and cultural variation in cognitive development and the connections between the two. Although the human evolutionary story is largely a story about cognition, this story is inseparable from two other stories, one regarding the social nature of the species and the other, the developmental story, which explains how high levels of cognitive, social, and emotional functioning manage to come about in the lifetime of an individual.

A few reasons why we don't share Tomasello et al.'s intuitions about sharing

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Abstract: Tomasello et al.'s two prerequisites, we argue, are not sufficient to explain the emergence of Joint Collaboration. An adequate account must include the human-specific capacity to communicate relevant information (that may have initially evolved to ensure efficient cultural learning). This, together with understanding intentional actions, does provide sufficient preconditions for Joint Collaboration without the need to postulate a primary human motive to share others' psychological states

Tomasello et al. propose two basic prerequisites for Joint Collaborative Activities: (1) understanding intentional actions of others and (2) a primary motivation to share psychological states of oth-

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ers. They argue that, whereas apes have the basics of prerequisite 1, they can't collaborate, because they lack prerequisite 2, the species-unique adaptation allowing humans to share goals and create Joint Collaborative Activities.

In our view, however, without a third prerequisite, the ability to *communicate relevant information* (Csibra & Gergely, in press; Sperber & Wilson 1986), Joint Collaborative Activities could neither be formed nor realized, even if both of Tomasello et al.'s preconditions were available. That the ability to communicate relevant information is necessary for Joint Collaborative Activities is clearly realized by the authors as apparent from their discussion of the "coordination problem" that permeates Joint Collaborative Activities. Participants must *negotiate and coordinate* at all levels of Joint Collaborative Activities by means of communicating relevant information: when agreeing on a goal to share, planning the sequence of intended means, allocating complementary roles, or scheduling complementary action plans. Neither could Joint Collaborative Activities be *performed* without communicating relevant information. Participants must monitor online their own and the other's actions, exchanging relevant information while comparing them to the planned sequence represented in their Joint Collaborative Activity. They also need to monitor the environment for unforeseen blocking conditions and be ready to communicate such relevant information to each other, and renegotiate how to modify the Joint Collaborative Activity online, changing complementary roles or action sequencing, if necessary.

One wonders why, having granted that the ability to communicate relevant information is necessary for Joint Collaborative Activities, the authors haven't included it as a third prerequisite in their magic formula producing cooperative intentionality in evolution and ontogeny. It's as if they considered the ability to communicate relevant information as derivable from the (more basic) capacity and motivation to share the psychological states of others. It's unclear to us, however, why (and in what sense) a motivation to share others' mental states could be more basic than the inclination to communicate relevant information to others, or how a primary motivation to share intentional mental states would imply or automatically yield the capacity to communicate relevant information.

On the contrary, we suggest to modify Tomasello et al.'s magic equation slightly. Imagine two mutant apes (or let's call them homo) who had (1) the capacity to fully understand others' intentional states, including their choice of action-plans, and (2) the ability to communicate relevant information, but would have somehow lost their gene coding for a primary motivation to share psychological states of others. Could they create and perform Joint Collaborative Activities without such a basic motivation to share others' mental states? We believe they could. Joint Collaborative Activities enable their participants to realize goals they couldn't achieve alone, yielding extra gains for them. That this is so could clearly be understood by the participants given their capacity for understanding the intentions of others, and by applying their ability to communicate relevant information they could negotiate a coalition, plan, and carry out a Joint Collaborative Activity to realize their egoistic but complementary interests. We see no reason why these fiercely competitive – but clever and communicating – creatures couldn't even make a habit of joining up for a promising Joint Collaborative Activity from time to time increasing their gains sufficiently to provide a selective advantage, eventually stabilizing their useful cultural habit. If this were indeed possible – and we submit it is – then a primary motivation to share psychological states of others could turn out to be unnecessary and substitutable by the ability to communicate relevant information in the race for the winning formula for the development of Joint Collaborative Activities – this time, however, among egoistically interested partners of a basically competitive nature. (Doesn't it sound so human?)

Furthermore, in contrast to Tomasello et al.'s hypothesis that apes don't collaborate because they lack the primary motivation to share the psychological states of others, we would emphasize the fact that apes lack the capacity to communicate relevant information (Gergely & Csibra 2005), which could explain why they cannot form Joint Collaborative Activities.

When comparing the plausibility of these alternative evolutionary formulae that claim to yield Joint Collaborative Activities, it may be informative to consider the evolutionary "just-so" stories offered about the conditions that may have facilitated the selection of a primary motivation to share psychological states of others *versus* the inclination and capacity to communicate relevant information to others. Tomasello et al.'s basic suggestion is that, as collaboration evolved due to the selective advantage it provided, the primary motivation to share the intentional mental states of others became selected as well since, by hypothesis, it's a necessary precondition for collaboration. However, as already argued, the evolution of collaboration can be plausibly accounted for *without a basic motivation to share others' psychological states*, if one assumes that the ability for understanding the other's intentional states *and* the capacity for communicating relevant information were both available.

As to the possible evolutionary origins of the inclination and capacity to communicate relevant information to conspecifics, we speculate that the increasingly sophisticated teleofunctional understanding of tools during hominid evolution led to complex skills of tool manufacturing that became practically impossible to acquire based on observable evidence through existing forms of social learning (including emulation) (Gergely & Csibra 2005). For example, when tools were manufactured at locations distant from their application, or when tools were used to make other tools, neither the goal nor the tool's efficient functional use was observable. Therefore, the procedure remained cognitively opaque for the juvenile who was deprived of the information necessary for inferring which (parts of) the observed action(s) or their multiple consequences were *relevant* for the tool's intended function(s) or affordances. This cognitive opacity represented a learnability problem endangering the chances of vertical transmission of important cultural skills that had significant survival value. This created the selective pressure for a new type of cultural learning mechanism that ensured transmission of relevant knowledge by making it *manifest* for the observer, leading to the emergence of the specialized communicative system of human "pedagogy" (Csibra & Gergely, in press). Humans became adapted both to communicate relevant knowledge to conspecifics and to be specifically receptive to such ostensive communicative knowledge manifestations. Knowledgeable humans became spontaneously inclined to ostensively manifest (not simply to use) their relevant cultural knowledge for the benefit of ignorant conspecifics, directing them to identify the relevant information to be learned. In turn, ignorant humans developed special sensitivity to ostensive cues that triggered a receptive attitude in them to infer and learn the new and relevant knowledge conveyed by the communicative manifestation.

Tomasello et al. view the formation of human culture as a mere by-product of an overarching species-specific drive to cooperate and share mental states with others. In contrast, our alternative proposal considers the species-unique capacity for cultural learning by communication of relevant knowledge to form the basis of human sociality and views the motivation for cooperation and sharing information as its consequences. But we certainly fully share Tomasello et al.'s belief that the best source of evidence to decide between these accounts will be provided by more data on the nature of early human development.

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Is shared intentionality widespread among and unique to humans?

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Abstract: We agree that motivation to share emotions and other mental states is crucial for communicative development, but human infants are highly selective in sharing mental states, and this is well taken evolutionarily. Young chimpanzees may also have motivation to imitate mothers. Thus, uniquely human cognition and culture may not be reduced to a few basic abilities and/or inclinations.

Because we assume that emotion influences cognition, with effects ranging from what is given processing priority to how widely information is used (Hatano et al. 2001), we welcome Tomasello et al.'s adding the motivational prerequisite of shared intentionality for uniquely human cognition and culture. However, we must point out two problems that their formulation seems to have, one technical and the other philosophical.

Shared intentionality with whom? In their formulation, Tomasello et al. almost neglected the issue of whom infants share intentionality with. We are afraid this neglect is a serious problem for our understanding of "we intentionality" that mediates cultural learning. We believe that human infants and toddlers do not want to share emotions and other mental states with every conspecific. We offer two arguments for the selectivity in sharing intentionality. Evolutionarily, whereas mind-reading ability is always useful, an overly extended intentionality sharing may be dangerous. Thus, infants and toddlers are expected to be highly selective in sharing those mental states initially and extend the act of sharing only gradually from the attachment or most reliable figure to other humans who are like the attachment figure and/or whom the figure interacts with positively.

In fact, studies on attachment strongly suggest this is the case. Here we indicate two essential features of social relationships of infants that inevitably affect the nature of shared intentionality. First, as soon as attachment is established toward the end of the first year, infants tend to share intentionality mostly with the attachment figure. As Campos and Stenberg (1981) demonstrated, the attachment figure, usually the caregiver, is the target of *social referencing*. Through references to facial, vocal, and gestural affect-specifying messages of the mother, 1-year-old infants can recognize her evaluation of a given situation. Also by referencing, the infants vicariously learn appropriate responses to the situation (Sorce et al. 1985). This evidence supports the affect-facilitation assumption of socialization; that is, affective figures can draw infants' attention and convey social influence (e.g., see Bandura & Huston 1961). For instance, attachment studies indicate that securely attached infants are characterized as compliant toward the mother, whereas incompliance and deviant behaviors toward the mother characterize insecurely attached infants (e.g., see Londerville & Main 1981). Thus, we can reasonably assume that infants share intentionality with special figures that they consider important.

Second, we know that infants and toddlers sometimes refuse to share intentionality. We agree with Tomasello et al. that infants in their early months are very sensitive to social contingencies. However, infants do not direct the hardwired capacity of sharing mental states indiscriminately toward others. Infants not only identify and love to interact with the specific attachment figure, but they also avoid other people. A *fear of strangers* is common among infants at around 8 months of age, which arguably shows that, for their safety, they reject unfamiliar people. Moreover, infants can often interact with a stranger if the mother stays in the room, but they reject proximal and physical contact with the stranger (Ainsworth et al. 1978).

Investigators of social relationships generally assert that even infants have multiple social figures, including parents, siblings, and grandparents (e.g., see Lewis 1982). In fact, infants are reported to have affective interactions not only with the mother but also with the father (Takahashi 1990). However, even these investigators do not believe that infants' sharing of intentionality is so widespread that it can be applied to virtually all conspecifics.

More evidence of that attachment-based selectivity comes from the case report of a long-term intervention of socially and physically deprived children in Japan (Fujinaga et al. 1990). When a 6-year-old girl and her 5-year-old brother were rescued from a small shack after 19 months of deprivation and taken into custody, their developmental levels were evaluated as equivalent to those of 1-year-olds or even younger normal children. However, they caught up on their development when they began to express attachment behavior toward each specific caregiver.

Another attempt to justify "human exceptionalism"? The foregoing concerns variations within the human species. Can this affective factor explain the between-species differences in individual and collective intellectual achievements? To generalize, can we maintain that *human exceptionalism* (i.e., unique human cognition and culture) be causally attributed to a few basic abilities and/or inclinations or perhaps a single one? Tomasello et al. seem to believe so, but their data are persuasive only with regard to the inadequacy of mind-reading ability alone, and not with regard to the adequacy of mind reading plus the motivation to share. This is the second philosophical problem.

A few recent studies by Japanese primatologists suggest that the "general ape line" has the motivation to share. Hirata and Morimura (2000) found that, in honey fishing (an experimental simulation of ant/termite fishing found in the wild), naive chimpanzees often observe after their failure their experienced partners and use the experienced partners' leftover tools. Hirata and Celli (2003) further suggest that infant chimpanzees acquire honey-fishing behaviors earlier than recorded in the wild not only by repeatedly observing the behaviors of experienced mothers but also by selectively using the tools often used by mothers. Matsuzawa et al. (2001), taking nut cracking as an example, suggest that young chimpanzees develop a strong affective bond with their mothers, who they use as models for imitative learning, like human apprentices do who are expected to possess a strong motivation to imitate. The mothers, like human masters, do not offer any form of active teaching but just tolerate the youngs' observation of their behavior. Matsuzawa et al. claim that infant chimpanzees' extended imitative learning is supported "by the motivation to copy the mothers' behavior" (p. 574). Why, then, are human intellectual achievements so different from those of chimpanzees? Our speculation is that there is only a small, quantitative difference in many basic aspects (including sharing intentionality) between humans and great apes, but the aggregate of a number of these small differences produces the remarkable qualitative difference in collaborative skills, culture, and cognition.

The interpersonal foundations of thinking

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Abstract: Tomasello et al. provide a convincing account of the origins of cultural cognition. I highlight how emotionally grounded sharing of *experiences* (not merely or predominantly intentions) is critical for the development of interpersonal understanding and perspective-sensitive thinking. Such sharing is specifically human in quality as well as motivation, and entails forms of self–other connectedness and differentiation that are essential to communication and symbolic functioning.

Some years ago, evidence emerged from studies in autism that there is a dissociation between affected children's relatively intact

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abilities to perceive and understand actions, and impaired abilities to perceive, engage with and understand subjective/emotional states (Hobson 1995; Moore et al. 1997). The developmental psychopathology of autism suggested that specifically in the domain of registering, responding to, sharing and co-ordinating *attitudes* we might find the developmental foundations for interpersonal understanding (theory of mind) and creative symbolic functioning – two areas of specific weakness in individuals with autism (Hobson 1993). For the past decade, Tomasello has stressed how it is vital for social interaction and understanding that an individual can read and relate to the intentions of others, and in the present article, he and his colleagues give fresh prominence to emotional relatedness in their theoretical scheme. Not only is this re-balancing welcome and important for integrating findings from research with non-human primates, but also it is vital for an understanding of the development of social and cognitive functioning in both typical and atypically developing young children.

But have Tomasello et al. gone far enough in this direction to accomplish their theoretical aims? True, they stress the developmental significance of person-to-person emotional engagement early in life, mostly to emphasize "the motivation to share psychological states," and at times they refer to (unspecified) "skills" that such engagement might involve. By and large, however, as their title suggests, the account pivots around the claim that "the foundational skill is understanding intentions," even though there is now the added dimension of *sharing* intentions and goals. What remains ambiguous is how the process of emotional engagement yields the forms of sharing that are critical for specifically human communication and thinking.

Perhaps what Tomasello et al. fail to convey is the role played by infants' responsiveness to *attitudes* in the story of early human development. It is not merely that emotional engagement is essential to sharing experiences (Hobson 1989), and that it motivates involvement with the bodily-expressed psychological states of others such that infants want to share, to communicate, to help and to inform others. It is also that infants' responsiveness to and identification with the attitudes of others, as these attitudes are directed both to the infant and to a shared world, structures experience in such a way that infants are in a position to learn about the nature of person-anchored subjective perspectives or takes on the world. In human interpersonal engagement, one is drawn to be aligned with the subjective states and outer-directed attitudes of others, while at the same time registering other-centred and self-centred aspects of experience. To express this differently, there is preconceptual mental architecture in primitive, cognitively unelaborated forms of social experience to provide the structure for what becomes mutual and reciprocal role-taking later in development.

Episodes of emotional engagement – and the processes of identification that configure human self–other connectedness and differentiation to make human emotional engagement specifically intense and moving – serve not only to establish sharing, but also to re-orientate an individual in attitude. Here it is critical that intentionality, and *a fortiori* shared intentionality, involves more than intentions. The intentional nature of mental orientations means that the world falls under such-and-such a description for one person, but may fall under another description for someone else, or indeed for the same person at a different moment. People can construe the world this way or that. Children come to understand this, and before their second birthday: They come to grasp that bodily-endowed people have different mental perspectives, and potentially different ways of experiencing as well as acting towards or understanding a shared world. Indeed, children come to realize their own potential to take up different orientations to reality, including those involved in symbolizing. My point is that, as Werner and Kaplan (1984) described, infants start from a primordial sharing situation and come to understand others' mental orientations as *both* similar to *and* distinct from their own, through their responsiveness to and assimilation of the attitudes of others.

Tomasello et al. consider that special forms of representation underpin human-specific forms of sharing intentions, but also entertain the possibility that dialogic representations are the developmental outcome of modes of interpersonal relatedness. However, they (more or less) reject the idea that identification might hold the key to the emergence of progressively supra-individual forms of representation, apparently because they are working with an impoverished notion of what identification entails.Identification proper includes a partial assimilation of the attitude and mental orientation of someone else, such that one preserves something of the "otherness" of the attitude perceived and assimilated. Tomasello et al. take the view that young children come to understand that others have minds on the basis of simulation and analogy with experiences of their own minds, a stance that Wittgenstein and other philosophers have revealed to be highly problematic (although such reasoning by analogy is commonplace, once other people are understood as such). For example, there would be no basis for infants to identify instances of their own mental states correctly if this were a precondition for understanding others, nor would there be adequate grounds for analogy if other persons were not *already* apprehended to be similar to themselves in having mental states.

If it is the case that the experience of dwelling in, and being moved by, the feelings of others is foundational not only for human relations, but also for increasingly articulated *understanding* of the nature of human takes on reality, then there is no need for simulation or reasoning by analogy to underpin knowledge of the nature of persons. It is highly likely that, as Tomasello et al. explicate, the ability to interpret goal-directed action makes its own contribution to growth in understanding minds – both one's own and those of others – and therefore to the emergence of creative, flexible, symbolic thinking. But human beings need more than a special form of *motivation* to complement their ability to interpret actions if they are to connect with (and cognitively benefit from) the subjective orientations of other people.

Identifying the motivations of chimpanzees: Culture and collaboration

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Abstract: Tomasello et al. propose that shared intentionality is a uniquely human ability. In light of this, we discuss several cultural behaviors that seem to result from a motivation to share experiences with others, suggest evidence for coordination and collaboration among chimpanzees, and cite recent findings that counter the argument that the predominance of emulation in chimpanzees reflects a deficit in intention reading.

Tomasello et al. suggest that differences in the cultural cognition of chimpanzees and humans can be explained by evolutionary differences in the ability to understand the intentions of others. These authors propose that, at some point after the divergence of humans and chimpanzees, the human lineage evolved an adaptation that increased our motivation to share emotional states, experiences, and activities with others, leading to a unique ability to engage in shared intentionality. This ability is argued to underlie many human cultural behaviors, from the use of language to the construction of social institutions. Although chimpanzees understand some aspects of intentions, Tomasello et al. argue that they show little evidence for the behavioral markers of shared intentionality that emerge during the course of human ontogeny, such

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as sharing emotions, coordinating actions, or collaborating with others.

Although this is a new and interesting idea, it may be worth acknowledging – especially given the pitfalls of negative evidence we have seen with regard to related phenomena, such as imitation and perspective-taking – that data cited as evidence that apes do not participate in shared intentionality are open to alternative interpretations. We believe that the differences between humans and chimpanzees are less clear-cut than Tomasello et al. imply. For example, they propose that chimpanzees do not interact together purely for the sake of sharing experiences, emotional states, and activities. However, chimpanzees participate in a number of cultural behaviors that involve no apparent reward other than sharing experiences with others and conforming to group norms. Examples of unrewarded behavioral copying include the spread of hand-clasp grooming (Bonnie & de Waal, in press; McGrew & Tutin 1978; Nakamura 2002), and the early nut-cracking attempts of young chimpanzees who spend many years trying to recreate the actions of their mothers without ever being directly rewarded for their efforts (Matsuzawa et al. 2001). Similarly, chimpanzees have been observed to conform to population-specific traditions even when alternatives may be more advantageous, such as the use of a less efficient technique for ant-dipping by individuals at Taï National Park in Côte d'Ivoire compared with individuals from Gombe National Park in Tanzania (Boesch & Tomasello 1998). For this reason, de Waal (2001) has proposed that chimpanzees are inclined to copy the behavior of bonded conspecifics, based on identification and a desire to fit in rather than rewards. Indeed, the phenomenon of chimpanzee culture is difficult to explain without acknowledging that a motivation to share experiences with others, and to do as others do, is intricately involved.

Tomasello et al. also state that it is almost unimaginable that two chimpanzees would collaborate together to achieve a common goal. They cite studies from their laboratory, in which, when given the opportunity to either compete or collaborate for a reward, chimpanzees are more skillful in the competitive situation (Hare & Tomasello 2004). Nevertheless, in other contexts, there is well-documented evidence for chimpanzee collaboration, such as soliciting support during coalition formation (de Waal & van Hooff 1981), holding up a "ladder" to be used by others to climb to out-of-reach places (de Waal 1982; Menzel 1972), mediated reconciliations (de Waal & van Roosmalen 1979), and the richly varied expressions of empathy and consolation that seem to set apes apart from monkeys (de Waal 1996; de Waal & Aureli 1997). Individuals in need of help are observed to use both vocalizations and bodily gestures to successfully encourage affiliates to come to their aid. Many of these interactions seem to involve an understanding of the other's needs and intentions as well as a close coordination between partners. Such collaborative interactions were studied by Crawford (1937) using a cooperative pull apparatus. In this task, two chimpanzees were presented with a heavy box containing fruit that could be pulled toward the chimpanzees' enclosure by using two ropes. However, the box was sufficiently weighted down so that it could only be dragged into reach if both chimpanzees pulled their respective ropes at the same time. Tomasello et al. argue that this study does not provide conclusive evidence for collaboration. However, in the original film footage, two juvenile chimpanzees can clearly be seen to act together, coordinating their actions so as to pull in unison. In addition, when one chimpanzee was reluctant to work, the other can be seen to guide her partner to the apparatus and provide gestures to encourage collaboration. Interestingly, once the food is drawn into reach, the unmotivated collaborator allows his partner to eat all the food. This footage is available for viewing at http://www.emory.edu/LIVING_LINKS/crawfordvideo.html.

Several experimental studies of social learning in apes particularly those involving tool use, have found evidence for emulation learning rather than imitation (Call & Tomasello 1994; Myowa-Yamakoshi & Matsuzawa 2000; Nagell et al. 1993; Tomasello et al. 1987). Tomasello et al. suggest that this indicates that chimps are not attuned to the action plans or intentions of the model. However, a recent study by Horner and Whiten (2005) showed that chimpanzees were able to use either imitation or emulation to solve the same task, depending on whether they could see the causal relationships that were involved. When the task was presented in an opaque condition such that participants could not see the causal relationship between the tool and the reward, they reproduced a relatively complete copy of the model's actions, including both necessary and unnecessary parts of the demonstration, in accord with imitation. However, when the same task was presented in a transparent condition so that the causal relationships were visible, the chimpanzees selectively excluded the unnecessary actions and reached the same solution by using a more efficient technique, in accord with emulation. The results of this study indicate that emulation may be the predominant learning mechanism in chimpanzees because it represents the most flexible and efficient strategy. Chimpanzees are able to employ imitation, but may do so mainly in situations where emulation is not possible. This seems to undermine the authors' argument that the predominant use of emulation by chimpanzees is due to a deficit in the ability to read intentions.

In light of the aforementioned issues, we feel that some specific questions remain with regard to the presence or absence of shared intentionality in chimpanzees. Nevertheless, Tomasello et al. have collated a large body of dispersed literature and proposed a number of hypotheses that are likely to generate great interest and new avenues of research in a field that has traditionally been treated with trepidation.

Dolphin play: Evidence for cooperation and culture?

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Abstract: We agree that human culture is unique. However, we also believe that an understanding of the evolution of culture requires a comparative approach. We offer examples of collaborative behaviors from dolphin play, and argue that consideration should be given to whether various forms of culture are best viewed as falling along a continuum or as discrete categories.

We are sympathetic with Tomasello et al.'s contention that human culture is unique, and are intrigued by their hypothesis that the human capacity for shared intentionality is the basis for our species' cultural accomplishments. However, as Tomasello et al. note, there is still much to learn. Much of what remains to be learned concerns the extent to which species other than humans possess culture, and the ways in which the cultures of nonhuman animals compare to those of humans. Obviously, if culture is defined as human culture, then only humans have culture. However, we believe that other species have culture, and that future investigations should focus on whether cultures on Earth are best viewed as falling along a continuum ranging from *no culture* to *human culture* or as discrete categories (see Morgan, 1894, for an early consideration of continuities and discontinuities in the evolution of mental abilities).

Tomasello et al. suggest that shared intentionality, their proposed prerequisite for human culture, involves both the ability to understand the intentions of others and the motivation and ability to share psychological states with others. The authors claim that only humans possess both types of abilities and that it is this combination that enables us to engage in collaborative activities involving shared goals and socially coordinated action plans. Although the authors believe that only humans engage in such activities, they recognize that human collaborative activities range

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from simple (taking a walk together) to complex (providing aid to victims of a large-scale natural disaster). Of the species existing on earth, only humans seem capable of large-scale collaborative ventures, but more simple collaborative activities seem within the capabilities of other species.

For example, our work with captive and wild dolphins suggests that at least some dolphin play behaviors are collaborative. We have observed young captive dolphins taking turns pushing one another along the surface of the water – a game that requires one dolphin to float stationary at the surface (typically on its side), allowing another dolphin (occasionally two other dolphins) to approach and gently contact the side of the floating dolphin, and then to push the floating dolphin sideways, oftentimes at high swim speeds. This dolphin game involves cooperation, and we have also observed dolphins switching from "pushee" to "pusher" during single play bouts, suggesting that the dolphins are in fact taking turns. We have also witnessed cooperative play with an object among a group of three wild rough-toothed dolphins (one youngster and two adults). While we were snorkeling, these three dolphins swam by, one of the adults trailing a piece of plastic from one of its pectoral fins. During the next 15 minutes, the three dolphins passed the plastic back and forth to one another. The cooperative nature of this behavior was evident in two respects. First, the dolphins did not attempt to steal the plastic from one another, but instead swam behind the dolphin with the plastic and waited for the plastic to be released. For example, the dolphin we first observed passed the plastic from its pectoral fin to its fluke and then let the plastic go, resulting in the trailing adult catching the plastic in its mouth. This dolphin then swam ahead of the other two dolphins, where it released the plastic for the now trailing adult to catch with one of its pectoral fins. Second, on several occasions, each of the two adults carefully passed the plastic to the young dolphin by placing the plastic close to the youngster's mouth before releasing the plastic. This suggested to us that the adults were ensuring the younger animal's participation. We have observed similar triadic interactions in captivity where dolphins initiate and maintain ball play with humans by tossing a ball to a person, waiting for the ball to be tossed back, tossing the ball back to the person, and so on. These examples of interactive play seem collaborative, at least in a simple sense, and, in conjunction with evidence of play signaling in other species, suggest the possibility of forms of interaction that might provide the basis for simple forms of culture.

Opponents of the notion of culture in nonhuman species might argue that we are reading too much into these play behaviors. Cautions concerning the dangers of overly rich interpretation of animal behavior have a long history (e.g., see Kuczaj 2001; Morgan 1894), but the same can be said for interpretations of human behavior, particularly that of children (see Brown 1973). For example, although human infants and toddlers are undoubtedly aware at some level of others' intentions and also seem motivated to share feelings and perceptions with others, the extent to which these abilities are present in young children and the extent to which they engage in "full-blooded cultural creation" is as much a matter of interpretation as it is a matter of empirical evidence. The main point of all this is that caution concerning overly rich interpretation is necessary for those who study all species, including humans.

To sum up, we believe that the study of culture would benefit from a comparative perspective, and that future work should address the question of whether various forms of culture are best viewed as falling along a continuum or as discrete categories. In addition, the extent to which the abilities highlighted by Tomasello et al. are also best represented as continuums (for example, "shared intentionality" might be at one end of a continuum that also contains "awareness of others" and "awareness of other's intentions," as well as the more basic ability to form an intentional plan of action) or as discrete categories is important for theories of cultural evolution. Determining the types of culture of which various species are capable and the cognitive prerequisites for such cultures will increase our understanding of the relative extents to which collaboration and cooperation are involved in the creation and maintenance of culture.

Steps toward categorizing motivation: Abilities, limitations, and conditional constraints

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Abstract: Tomasello et al. have not characterized the *motivation* underlying shared intentionality, and we hope to encourage research on this topic by offering comparative paradigms and specific empirical questions. Although we agree that nonhuman primates differ greatly from us in terms of shared intentionality, we caution against concluding that they lack all aspects of it before other empirical tools have been exhausted. In addition, identifying the conditions in which humans spontaneously engage in shared intentionality, and the conditions in which we fail, will more fully characterize this ability.

The target article raises far more questions than it answers, but the nature of the questions suggests to us that Tomasello et al. are onto something important. *Shared intentionality* is described as the outcome of a union between primate-general understandings of goal-directed behaviour and human-specific social motivations. *Motivation* may be an appropriately vague term at this point in theory development, but obviously it is not detailed enough to explain fully the human-nonhuman socio-cognitive distinction. How much of this motivation is intrinsic and how much is extrinsic? What are the underlying mechanisms? Do nonhuman primates share at least some aspects of this motivation? We push here for a detailed characterization of this motivation and hope to offer some steps forward through (1) comparative paradigm development and (2) important future experimental questions.

Recent comparative research has proven fruitful for characterizing socio-cognitive abilities in human and nonhuman primates (e.g., aspects of intentional action and perception [Hare et al. 2000, 2001]). We suggest that shared intentionality should continue to be approached in this manner – we are not as ready to dismiss chimpanzees in the *present/absent* manner as Tomasello et al. do. Of course, we are likely *not* going to find a chimpanzee system of shared intentionality that is on par with ours, but such research will lead to a more specific sense of where their limitations lie and what makes the human system work. Indeed, as Tomasello et al. point out, most attempts to find chimpanzee instances of cooperation and collaboration toward goal completion have come up empty-handed.

However, just as the studies by Hare et al. (2000, 2001) demonstrate the importance of task designs that fit natural chimpanzee social, goal-directed behaviour (i.e., competitive tasks), we argue that there also might be tasks that are more likely to *motivate* shared intentionality within this species. In past experiments, subjects were asked to cooperate toward a common food goal, yet this is not a species-typical behaviour for chimpanzees. We suggest that a testing situation is needed in which shared intention is required to compete or protect against a third entity. There is some suggestive evidence that this might work. In an ongoing project by Boysen et al. (in preparation) – using a paradigm modeled after the work by Cheney & Seyfarth (1990) – a chimpanzee dyad is placed in close proximity to a predator: an experimenter with a tranquilizer dart gun. Chimpanzees will engage in species-typical alarm behaviour toward their partner (e.g., vocalization and swaying) more often when the partner is ignorant (lacks perceptual ac-

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cess) of the presence of the predator than when he is knowledgeable (has perceptual access). Such behaviour is often followed by the partner's movement away from the testing arena into safety. These data seem to meet Tomasello et al.'s criteria for *dyadic engagement* and may even approach *triadic engagement*: the chimpanzees may be perceptually monitoring the goal-directed behaviour and perceptions of their partners, and engaging in informative signal production, possibly toward the shared goal of the endangered chimpanzee's safety. This type of design combines the competitive elements that are ecologically relevant to chimpanzees (e.g., opposition to a third party) and the cooperative elements that are essential to sharing intentions (e.g., between the two chimps). We offer this as a stepping-stone for the future comparative examination of shared intentionality and argue against dismissing these abilities completely in nonhumans so early in the research endeavour.

Of course, the very fact that we have to design particular types of tasks to find evidence of shared intentionality capacities in nonhuman primates speaks to some obvious differences between us and them. As detailed in the target article, humans do this flexibly across a variety of situations. But do humans do it equally across all situations? Do situations differ in terms of the level or type of motivation for social engagement? Perhaps humans, too, are more likely to engage in shared intentionality – and exhibit it earlier in development – when the stakes are high (e.g., working together against a common enemy), compared with situations in which the goal is less evolutionarily relevant.

Just how good are we at shared engagement, and what cognitive mechanisms might underlie it? An examination of the conditions under which humans *fail* to engage in shared intentionality may help to shed light on the mechanisms underlying the ability (in much the same way that examining the specific conditions under which humans fail to appreciate fully what others know helps characterize *theory of mind*, [e.g. see Birch & Bloom 2004]). In fact, as humans, we must spend a lot of time enculturating shared intentionality in children (e.g., group projects in school, team sports). As much as we seem to develop an intrinsic social motivation to engage in some truly collaborative activities, we also sometimes require external motivation. In this way, the relationship with the development of culture appears bidirectional – shared intentionality can enable culture creation, and culture can encourage shared intentionality.

In sum, the function and existence of shared intentionality even before the second year of life is made quite clear by Tomasello et al., and we agree that it is a strong candidate for an important socio-cognitive difference between humans and other animal species, including our closest primate relatives. However, we propose that a detailed characterization of the social motivation underlying shared intentionality is still required and may be achieved by identifying both abilities and limitations in humans as well as nonhumans.

Shared intentions without a self

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Abstract: Shared knowledge of intentionality as well as shared knowledge of anything depends on the organism's understanding of itself, others, and the possible relations between self and other. This understanding involves mental representations of *me*, which emerges in the second half of the second year in the human infant, and it is this ability that gives rise to humanlike social understanding and complex self-conscious emotions.

The problem Tomasello et al. present is an important one for it asks how shared intentionality comes about and, most importantly, how the use of shared intentionality becomes the basis of all human exchange. Their premise is that the understanding of intentionality of others is not sufficient for humanlike cultural activities; what is needed, in addition, is shared intentionality, the motive to share things with others.

In the study of social cognition, we, as well as others, have argued that a person needs knowledge of themselves, others, and the relationship between self and other (cf. Asch 1952; Hamlyn 1974; Lewis & Brooks-Gunn 1979a, 1979b; Merleau-Ponty 1964). I have suggested that the development of social cognition proceeds in the following order: (1) I know, (2) I know I know, (3) I know you know, and finally (4) I know you know I know (Sullivan et al. 2003). R. D. Laing's *Knots* (1970) makes a similar point when he speaks of the complex interconnection between people, best captured in such meaningful language phrases as "I know, you know, that I know, you know that I will go to the football game on Saturday." The target article speaks to this same issue.

My concern here is how "by 9 months . . . infants understand that people have goals and persist in behaving until they see that their goal has been reached . . . [that people are] happy when the goal is reached and disappointed if it is not" (sect. 2.4, para. 1). Certainly, we have learned that infants know a lot. In fact, the history of infant research in the last 45 years has been one in which the infant has gone from the James (1950) insensate unformed organism to a highly complex one. But the question remains as to what kind of knowledge is responsible for these newfound skills and abilities? As Putnam (1981) has warned us, just because an ant can trace a face in the sand does not necessarily imply that the ant knows anything about faces. Indeed, I should like to argue that just because the 9-month-old infant can perceptually discriminate between two conditions does not necessarily mean that the infant knows about them if we mean that they know as we adults know. Perhaps we are back to the rheostat – in this case a very complex one. As I have tried to argue, the first step, "I know," is equivalent to machine or zombie knowledge. It is not until the second step, "I know I know," that we can distinguish between machine ability and mental states – in particular, the mental state of *me* – for not until we have such a mental state of me, "I know I know," is it possible to have the fourth step or true social cognition, namely, the interaction of symbols and knowledge between two humans. This shared intentionality is possible only between two selves, both of which have knowledge about themselves and others. Certainly, there may be early precursors of such knowledge. There is no question that the complexity of the machine that exists in infants at very young ages can allow for subsequent shared intentionality. Nevertheless, it is not enough.

Our work (Lewis 2003; Lewis & Ramsay 2004) has shown a slow development toward the mental state of the idea of me. We have shown that starting around 15 months, infants exhibit three classes of coordinated behavior – self-recognition, personal pronoun usage, and pretend play – which suggest the emergence of this mental state. Moreover, there is little evidence to indicate that the emergence of this mental state has much to do with environmental causes (Lewis et al. 1985). In fact, data from magnetic resonance imaging studies strongly suggest the importance of maturational factors, in particular the myelination of brain regions thought to support this mental state of me (Carmody et al. 2004). Such data suggest that the maturation of particular brain regions may be the cause of the emergence of the mental state of the idea of me – the "I know I know" and "I know you know" – which then subsequently allows for "I know you know I know." There is little doubt – at least at this point – that the earlier capacity of the machine as exquisitely described by Tomasello et al., can possess this knowledge. The complexity of the organism from early ages on may become the material used once the mental state of me emerges. However, it may not be the cause of the mental state itself. Rather, it remains to be shown that much of the abilities ascribed to infants reflect only "machine ability," and not until the emergence of the mental state of the idea of me can this machine ability be put to use in a humanlike fashion.

Interestingly, the emergence at 15 months of this capacity "I

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know I know" also gives rise to complex humanlike (also found in some apes) emotions – those I have called the self-conscious emotions, such as shame, guilt, embarrassment, and pride (Lewis 1997) as well as the social skills of imitation, empathy, and sharing (Lewis 2005).

Finally, a word about motivation. It would seem that a self – a system with knowledge about itself – would be interested in and be motivated by the similarities and differences between the self and others. "Like me" or "not like me" becomes an important feature in the world – one that becomes part of the cultural knowledge, the transmission of ideas, and the cause of likes and dislikes. Without an understanding of the mental state of the idea of me, without the knowledge of "I know I know" (whether conscious or not), the understanding of human behavior and human artifacts is incomplete.

Motivation is not enough

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Abstract: Tomasello et al. provide a new account of cultural uniqueness, one that hinges on a uniquely human motivation to share intentionality with others. We favor an alternative to this motivational account – one that relies on a modular explanation of the primate intention-reading system. We discuss this view in light of recent comparative experiments using competitive intention-reading tasks.

In the 1990s, Tomasello and colleagues argued that the ability to represent mental states was a uniquely human capacity. They further argued that it was this representational capacity that accounted for the singular attainments of human culture; without the ability to represent mental states, nonhuman primates (hereafter primates) were consigned to remain in our species' cultural dust (Tomasello et al. 1993). Over the past few years, Tomasello and colleagues have gathered a wealth of compelling empirical evidence suggesting that their initial hypothesis was mistaken: primates can in fact reason about the mental states of others in some (usually competitive) contexts (e.g., see Hare et al. 2000, 2001; see also Flombaum & Santos 2005). As a result, there must be more underlying our cultural uniqueness than simply the ability to represent mental states. In the target article, Tomasello et al. revise their prior conclusions to account for these new data. They posit a new feature of human cognition to explain our cultural sophistication – one that that is argued to be absent in primates. This time that feature is our unique capacity for shared intentionality.

Tomasello et al.'s new account of human cultural uniqueness has a noticeably different flavor. The older account – that primates cannot reason about mental states – was a distinctly *representational hypothesis*. Primates lacked a crucial piece of cognitive machinery; they could represent the behavior but not mental states of others. Under the new account, however, primates *can* in fact represent the mental states of others. The distinction is that they are not *motivated* to share in these mental states. As they put it, "[O]ur claim [is] that there is a special kind of shared *motivation* in truly collaborative activities . . . each interactant has goals with respect to the other's goals" (sect. 3, para. 3, emphasis added). This motivation is what primates seemingly lack: "The overall conclusion would thus seem to be that although apes interact with one another in myriad complex ways, they are not motivated in the same way as humans to share emotions, experiences, and activities with others of their own kind" (sect. 4.1.2, para. 5). Note that there is a distinct epistemological difficulty with such a motivational argument. Whereas a representational account has the advantage of making firm predictions about the structure of primate thinking, an account expressed in terms of motivation is more poorly constrained. In particular, how would we go about defining motivation in an experimentally quantifiable way? We worry that the inherent subjectivity of motivation as an explanatory construct makes Tomasello et al.'s new hypothesis dangerously close to nonfalsifiable.

A further potential problem with Tomasello et al.'s explanation of human cognitive uniqueness is that it fails to account for an important pattern in the existing data on primate intention reading. As the authors note in their target article (and which has been reviewed elsewhere [see Hare 2001; Hare & Tomasello 2004; Tomasello et al. 2003]), chimpanzees' performance on intention-reading tasks is often context dependent. Hare and Tomasello (2004), for example, have demonstrated that chimpanzees exhibit significantly greater proficiency at an object-choice task when it is presented in a competitive rather than cooperative context. This result is just one instance of a larger trend in the recent literature – that primates' understanding of mental states is most strongly evidenced in competitive situations. Again, these researchers have tended to account for this empirical pattern in terms of motivation. With regard to the object-choice task, they argue that subjects performed better "because they were more motivated to succeed and paid more attention when competing" (Hare & Tomasello 2004, p. 580).

We, however, believe that the extant data support an alternative account. We favor the view that the intentional attribution abilities of nonhuman (and possibly human) primates are localized within a domain-specific module – one whose application in primates is confined to competitive social interactions. We use the term *module* to refer to a cognitive system that has access only to specific informational input and whose internal operations are hidden from external cognitive processes (see Fodor 1983; Scholl and Leslie 1999); the larger cognitive system, under this view, has access only to the module's final output. Note that these properties of modularity provide a sensible framework for interpreting the apparent context sensitivity of primates' ability to reason about the mental states of others. First, the existing data are consistent with a module whose input conditions are satisfied only by competitive social contexts. When such a competitive situation arises, the module provides output – presumably in the form of imputed goals or predicted behaviors – for external cognitive processes to manipulate; in noncompetitive situations, the module remains silent. Second, the modular account resolves an irksome "chicken and egg" problem: how do primates go about *detecting* competitive situations in the first place? It is difficult to imagine a means of detecting competitive situations that does not entail reasoning about the intentions of others, yet primates appear to reason about the mental states of others only in competitive situations. This seeming circularity is resolved by positing a modular process. Presumably the intention-reading module continuously receives input regarding the behaviors of conspecifics and uses this information to continuously predict future behaviors. These predictions, however, output to the rest of the cognitive system only when the inputs to the system are competitive in nature. In other words, a modularized mechanism enables detection of competitive contexts and subsequent intentional reasoning to be reduced to a single process.

The target article provides an excellent reflection of its authors' scientific rigor. We wish to commend Tomasello et al. both for their willingness to challenge their own prior conclusions and for generating some of the best experimental innovations in the field of primate cognition today. Our goal in this commentary has been to add to the valuable theoretical foment that this enviable intellectual productivity has made possible. We believe that the available data enable us to go beyond the potentially problematic notion of motivation and to posit instead a more readily testable architectural hypothesis.

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Causal curiosity and the conventionality of culture

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Abstract: Tomasello et al. argue that cultural cognition derives from humans' unique motivation to share psychological states. We suggest that what underlies this motivation is children's propensity to seek out the underlying causes of behavior. This propensity, combined with children's competence at it, makes them especially skillful at acquiring the intentional, conventional, and reliable forms that constitute culture.

The ability to predict and explain the behavior of others is essential for navigating the social world. Probably the most fundamental and universal aspect of human social reasoning is the capacity to read intentions. Given how pervasive intentions are in human interaction, it is not surprising that infants show rudimentary intentional understanding in the first year of life. Based on recent findings, however, Tomasello et al. suggest that chimpanzees also seem to have a basic understanding of intentional actions and perceptions (though see Povinelli & Vonk 2003). In their article, Tomasello et al. take these findings to imply that intentional understanding alone cannot account for human cultural cognition, leading them to suggest that the human motivation to share psychological states – dubbed "shared intentionality" – is the critical distinction between humans and other species.

We strongly agree with Tomasello et al. that, in addition to being remarkable mindreaders, humans are highly motivated to share their psychological states and to understand those of others – the two proposed components of this uniquely human shared intentionality. What we fail to see in Tomasello et al.'s proposal is an explanation for *why* human children might have such a motivation. We propose that the reason for this motivation may rely on children's understanding of intentions as *causal* and thus *explanatory* of behavior, something nonhuman primates and some children with autism might not do.

Support for this idea comes from studies demonstrating that human infants go beyond merely interpreting actions as goal directed and being sensitive to eye gaze – skills that Tomasello et al. point out may be shared by nonhuman primates and children with autism. In addition to these basic intentional abilities, human infants – but not other species – possess the capacity, and the curiosity, to reason about the underlying causes of human action. From early on, infants distinguish between psychological and physical events, as demonstrated by the differing expectations they hold for the behavior of objects and people (Spelke et al. 1995). In the physical world, infants are driven to account for impossible events intended to violate their expectations, by reasoning about their underlying causes (Baillargeon 1995). This drive to search for causes extends to the social world, as evidenced by infants' reasoning about the goals and intentions underlying human action, and their willingness to impute intentions to nonhuman agents if their behavior is rational (Gergely et al. 1995; Woodward 1998). The speed and apparent ease with which these early causal understandings – be they domain specific (Wellman & Gelman 1998) or domain general (Schulz & Gopnik 2004) – emerge, suggests that causality comprises a developmental primitive. By 3 years of age, children's naïve psychology allows them to explain human action in terms of psychological states such as intentions, desires, and emotions (Bartsch & Wellman 1989; Hickling & Wellman 2001). In contrast, most children with autism struggle to comprehend the actions of others.

How could this curiosity for causal knowledge – especially intentions – make human children better learners of culture? First of all, this causal propensity makes children realize that, in order to relate to others, it is crucial to adjust to and be sensitive to not only superficial manifestations (e.g., behavior), but also to the underlying psychological states from which these manifestations derive. In this sense, imitative acts are not done for the sake of sharing psychological states, but perhaps as attempts at learning (and testing) a relevant action. The finding that children imitate intended acts (e.g., see Gergely et al. 2002; Meltzoff 1995) can be taken as evidence for children's critical analysis of what should and should not be learned.

Second, this kind of analysis might be especially pertinent for cultural manifestations. To a great extent, these manifestations consist of arbitrary, yet stable and conventional forms. How people in a certain culture open doors is idiosyncratic. How they handle a fork, or what a red stop light means, less so. What they call a four-legged mammal that barks, even less. Attention to intentions, coupled with the drive to interpret them causally, enables children to make sense of all of these events. Crucially, the relative stability and conventionality of the latter three further enable children to make sense of these events without having to recompute the intentions every time. In other words, artifacts, symbols, and linguistic forms are ready-made shortcuts to people's intentions, and by being good at detecting intentions and understanding their causal underpinnings, children are especially disposed to acquire these short cuts.

Evidence of children's capacity to understand the intentional and conventional components of artifacts comes from studies showing that preschool children designate consistent functions to artifacts (Kelemen 1999), and extend artifact names on the basis of their intuitions about what an artifact was intended to be (Diesendruck et al. 2003). The notion that "we agree that artifacts are created for a reason" (Bloom 1996) results from our species-specific curiosity about causes and the human capacity to infer them. Even younger children have been found to get so "stuck" on the conventional use of artifacts that they sometimes have trouble assessing when an action is inappropriate. For instance, 18- to 30-month-old children often make scale errors, attempting in vain to perform impossible actions on miniature objects, such as trying to sit on a doll's chair or get into a small toy car (DeLoache et al. 2004). Lastly, children understand that words, but not other arbitrary information, are conventions shared by all members of a linguistic community and are used intentionally by speakers to convey particular meanings (Diesendruck & Markson 2001).

In sum, we propose that children's propensity to acquire cultural norms – via artifacts, symbols, and language – is a consequence of the intrinsic human curiosity to understand causes, the capacity to do so, and the greater reliability of cultural forms.

Motivation, self-regulation, and the neurodevelopment of intention sharing

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Abstract: Research on the affective and neurodevelopmental correlates of infant joint attention skills support several of the hypotheses raised by Tomasello et al. regarding the development of the capacity to share intention with others. In addition, research and theory suggests that self-awareness and self-regulatory processes may play a role in the development of this vital human ability domain.

Tomasello et al. have suggested that social-motivation factors may contribute to the evolution and development of the human capacity to share experiences and intentions with others. Although compelling, testing this hypothesis is challenging. Nevertheless, studying the affective correlates of infants' triadic and collaborative joint attention skills, which constitute an early index of intention sharing, may be revealing in this regard.

It appears that the expression of positive affect to social partners is an integral component of infants' self-initiated joint atten-

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tion (Initiates Joint Attention, or IJA) bids, and that an attenuation of positive affective sharing plays a role in joint attention impairment in autism (Kasari et al. 1990; Mundy et al. 1992). If positive affect is indicative of motivation, these observations are consistent with the hypotheses that social motivation plays a role in the development of sharing intentions with others (Tomasello et al.'s article) and the neurodevelopmental impairment of joint attention in autism (Mundy 1995). Frontal processes involved in motivation (i.e., associating rewards with goal-directed activity) have also been associated with infant IJA development (Dawson et al. 2002a; Nichols et al., 2005).Moreover, there is a shift from *reactive* affect in IJA (smiling after looking from an object to a social partner) to *anticipatory* affect (smiling at the object and then conveying the affect to the social partner) between 8 and 10 months (Venezia et al. 2004). This may indicate an important change in the integration of affect, cognition, and intentional control in the early development of intention sharing. Thus, current research offers some support for the social-motivation hypothesis of intention sharing. However, the fundamental nature of the motivation processes involved remains to be described.

Tomasello et al. also suggest that the capacity to monitor and regulate goal-directed actions, and to represent the goals of self and other, provides a cognitive foundation for sharing intentions. Neurodevelopmental research and theory ascribe similar cognitive functions to triadic joint attention (Mundy 1995, 2003). The ability to follow gaze and respond to the triadic joint attention bids of others (Responds to Joint Attention, or RJA) is associated with temporal and parietal cortical functions serving attention disengagement, orienting, and social perception (e.g., see Mundy et al. 2000; Vaughan & Mundy, in press). For example, primate studies indicate that the superior temporal sulcus (STS) contributes to the processing of gaze direction versus the processing of the direction and orientation of limb movements (e.g., see Perrett et al. 1992). However, a subset of limb movement cells appears to be modulated by activity of the gaze-following system (Jallema et al. 2000). Thus, the *combined* analysis of direction of visual attention and body movements of others by STS systems provides an important source of information that gives rise to the capacity to detect intentionality in others (Jallema et al. 2000).

IJA may be associated with the dorsal-medial frontal cortex and anterior cingulate complex (DMFC/AC [Caplan et al. 1992; Henderson et al. 2002; Mundy 2003; Mundy et al. 2000]). The DMFC/AC contributes to the planning, self-initiation, and self-monitoring of goal-directed behaviors, including visual orienting (e.g., see Rothbart et al. 1994) and the capacity to share attention across dual tasks, or representations (Stuss et al. 1995). Thus, the DMFC/AC plays a critical role in the maintenance of representations of self, a social partner, and third object/event that is critical to the capacity to share intentions (Mundy 2003; Mundy et al. 2000). The DMFC/AC is also be involved in the motivational mediation of goal-related behavior. The DMFC/AC plays a critical role in the supervisory attention system (SAS) (Norman & Shallice 1986), which functions to guide attention deployment and behavior, depending on the motivational context of the task (e.g., see Buch et al. 2000).

Ultimately, the DMFC/AC is involved in representing the self, and self-monitoring of goal-related behavior, as well switching attention between internal proprioceptive (self information) and exteroceptive information about external events (e.g., see Craik et al. 1999; Faw 2003; Mundy 2003).

Frith and Frith (2001) argue that the DMFC/AC integrates self-monitored information with perceptions processed by the STS about the goal-directed behaviors and emotions of others. This putative facility for integrating proprioceptive "self" information with exteroceptive "other" information has been called a *social executive function* (SEF) of the DMFC/AC (Mundy 2003), and a breakdown of this SEF may play a role in joint attention and social-cognitive impairment in autism (Mundy et al. 1993). Theoretically, the DMFC/AC facility to compare and integrate the actions of self and others contributes to the capacity for simulation (Stich & Nichols 1992) and the ability to infer the intentions of others by matching them with representations of self-initiated actions (Mundy 2003). Once this integration begins, a fully functional, adaptive human social-cognitive system emerges with experience (Frith & Frith 2001). Indeed, there is evidence that DMFC/AC activity is associated with social-cognitive performance on theory-of-mind measures in adults (e.g., see Calarge et al. 2003). Thus, understanding of intentions in others may be an emergent property of the gradual phylogenetic and ontogenetic development of a myriad of integrated functions of the human DMFC/AC and temporal cortical systems.

Of particular importance here may be the development of the comprehensive DMFC/AC capacity for self-monitoring and self-regulation of goal states. From a constructivist perspective, infants need to self-monitor and self-regulate (*exercise* control of) their own goal-directed behaviors and emotions *in order* to understand goal-directed, intentional action in others (Mundy 2003; Tomsello et al.). Thus, in addition to motivation and representational ability, the constructs of self-awareness and self-regulation may be important to consider in theory on triadic joint attention and the capacity to understand intentions in others. Supporting this conjecture, self-recognition (self-awareness) has been associated with infant IJA development (Nichols et al., 2005), and 6-month RJA predicts self-regulation during delay of gratification in 2-year-olds (Morales et al., 2005). Infant IJA and RJA are also associated with behavior and emotion regulation among 30- to 36-month-olds (Sheinkopf et al. 2004; Vaughan et al., submitted), and infants exposed to less optimal caregiving associated with dysregulated behavior display attenuated IJA development (e.g., see Claussen et al. 2002).

These observations are quite consistent with the insights of Tomasello et al. and point to a persuasive convergence of perspectives on the human capacity to share experience with others. They also suggest that self-awareness and self-regulatory processes may be neurodevelopmentally bundled with social-motivation and social-cognitive processes in both the phyologenetic and ontogenetic development of the capacity to share experience, as well as in the resultant human capacity for cultural cognition.

Do infants understand that external goals are internally represented?

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Abstract: Evidence for infants' sensitivity to behavior being goal oriented leaves it open as to whether they see such behavior as being designed to lead to an external goal or whether they see it, in addition, as being directed by an internal representation of the goal. We point out the difficulty of finding possible criteria for how infants or children view this matter.

Organisms can be described as having goals even when they do not have an explicit representation of the goal-to-be-achieved that directs behavior. For example, some plants turn towards light, which McFarland (1989) described, therefore, as *goal-seeking*. Tomasello et al.'s exemplary thermostat can recognize a goal when it obtains, so can be described as *goal-achieving*.

Tomasello et al. recognize the importance of such distinctions by pointing out that much confusion resulted from failure to clearly distinguish the *external goal* (a potential future state of the environment) and the *internal goal* (a behavior-guiding mental representation of the external goal). Instead, Tomasello et al. decide to use "goal" *simpliciter* for internal goal and "desired result" for external goal. Unfortunately, this decision can only aggravate

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conceptual confusion. When technical definitions go against natural meaning, as in this case, readers tend to fall back into natural language meaning. Even the authors appear to do so. For example, in section 2.2 they write, "[I]nfants understand . . . actors routinely go around obstacles to get to *goals*" (our emphasis). This certainly can't mean according to their definition that "infants understand actors go around obstacles to get to *their internal representations of their desired results*."

Tomasello et al.'s definition of *goal* is, however, not just an unfortunate technical use of language but misleads in substance by suggesting without argument or evidence that infants understand purposive behavior as guided by internal representations of goals. When reviewing infants' understanding of the pursuit of goals in section 2.2, the authors routinely describe infants as seeing observed behavior as "goal-directed action," which, according to their definition would be phrased "action directed by the internal representation of a goal." Their descriptions thus entail that infants understand goals as internally represented without giving any reason or evidence for such a claim.

Such reasons would be particularly valuable because of the importance of the distinction in question. We know of no obvious way of determining whether children see behavior as *goal-directed* (directed by an internal representation of a goal) in distinction to seeing behavior as *goal-oriented*, without assuming an internal representation of the goal.

The relevant contrast is between *teleological* explanations and *intentional* or *mentalistic* explanations. A completely *externalist* (no internal states involved) teleological explanation sees behavior as a function of the present state of the world (circumstances), some future state (goal) and rudimentary rationality – that is, that behavior will occur that transforms reality into the goal state. This externalist view also applies to inanimate objects without internal, behavior-directing states, like a pendulum whose goal is to come to rest at the lowest possible point (according to Aristotle [Kuhn 1977]).

An externalist view also provides limited understanding of "intelligent" mechanisms like temperature-regulating systems. Knowing the external temperature and the system's target temperature (external goal) enables prediction of whether the system will switch the furnace off (behavior). Ways of manipulating the system intelligently remain limited to changing the external circumstances (e.g., to heat up the room). Other intelligent means of intervention become possible only if we understand more of the internal workings.

According to an *internalist* view of intelligent behavior, the system/organism's behavior does not depend directly on the state of the world and some future goal state but on internal representations of these states. Here we need to distinguish two levels of understanding. In the case of the thermostat, we have full *physiological* understanding of the internal parts of the thermostat (bimetallic strip that bends when heated and touches a contact point, etc.) and their functional role (bimetallic strip curvature represents external temperature, contact-point setting represents goal, etc.). At the level of folk psychology (theory of mind, mentalism), however, we have no understanding of the actual internal parts; we only surmise that there must be some part registering the external temperature (belief), another part representing the goal value (desire), and a comparison mechanism that takes action when the two values coincide (practical reasoning mechanism).

Nevertheless, we gain an advantage over the purely externalist approach in two ways:

1. *Intentionality*. We can understand that the system represents the external circumstance in a particular way, which depends among other things on the information the system has. Given misinformation it will misrepresent the circumstances (false belief). Its subsequent behavior can then be predicted or explained, in a way not possible with a purely externalist account.

2. *Manipulability*. Understanding that the internal representation of external circumstances depends on information enables a novel means of manipulating the system's behavior. We can make it delay switching on the furnace by deception – that is, by heating up its sensors to make it "believe" the room is still hot.

Children's understanding that beliefs are internally represented has been assessed by their ability to predict, explain, or induce false beliefs. Can similar techniques be used for testing understanding goals as internally represented? Curiously, there is no straightforward analogy to false belief, because goal representations do not depend on manipulable ingoing information, and goals cannot be misrepresented. If the thermostat represents the goal as 31°C, then that *is* the system's goal, even though people might prefer 21°C. In other words, the (external) goal is determined by its internal representation (direction of fit [Anscombe 1957; Searle 1983]), whereas, for beliefs, the external circumstance is not determined by what the system believes it to be.

A tempting line of thought is that understanding subjective preference requires an understanding of internal representation of goals, because subjectivity smacks of *Intentionality*. Indeed, infants in their second year (Repacholi and Gopnik 1997) understand that someone else can want broccoli, which the children themselves find revolting. However, a difference in goals can be understood without understanding goals as internally represented (see Perner et al., 2005). The infants simply understand that one of this (admittedly strange) person's *external* goals is to eat broccoli.

In conclusion, seductive choice of terminology can suggest that infants take an internalist, mental view of goals, but we find it difficult to specify hard criteria for determining when they actually do take such a view.

From action to interaction: Apes, infants, and the last Rubicon

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Abstract: Tomasello et al. have presented a position that is grounded in a conservative perspective of cultural learning, as well as in a rich interpretation of recent findings in early social cognition. Although I applaud their theoretical framework, I argue that data from studies of human infants are not necessarily consistent with the developmental picture that they describe.

Approximately one decade ago, Tomasello et al. (1993) brought forth the argument that human beings' understanding of conspecifics as intentional or mental agents is a species-unique ability that renders humans capable of participating in cumulative cultural evolution. In their present thought-provoking article, Tomasello et al. draw on a wealth of recent research regarding the cognitive capacities of nonhuman primates and human infants as a means of revisiting the issue of cultural cognition. The authors conclude that nonhuman primates have a greater understanding of intentional agents than was previously believed. Furthermore, they maintain that the crucial difference between human cognition and that of other species centers on the ability to participate in activities involving joint intentions and attention or what they refer to as *shared intentionality*. They propose that the ontogeny of the ability for collaborative engagement occurs in three stages over the first year of human life as a joint product of the understanding of intentional action (also found in other apes) and the motivation to share psychological states (species specific). It is evident that Tomasello et al. are well placed to provide an evolutionary account of human cognition, seeing as they occupy a unique niche in the field of cognitive science. Indeed, a substantial portion of the published research on social cognition in human and nonhuman primates over the last decade can be attributed to them. In the following commentary, I address three principle is-

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sues that arose throughout their article: (1) the support (or lack thereof) for the proposed developmental milestones in the understanding of intentional action and shared intentionality, (2) the significance of autistic children's social-cognitive skills in terms of the current proposal, and (3) whether recent speculation and data on the human mirror-neuron system might provide challenges for the proposal.

With respect to human ontogeny, three developmental milestones are documented concerning the understanding of intentional action and shared intentionality. The first level of shared intentionality that comprises a developmental milestone is observed at 3 months in early dyadic engagements, also called *protoconversations* (i.e., conversations that reflect shared emotions and behaviors). According to Tomasello et al., this level requires that the two conversational partners regard and understand each other as animate agents. To my understanding, there is as yet no direct empirical evidence showing that infants at that age understand that people spontaneously produce behavior, a requisite of animate agents. The discrimination of biological from random motion that has been demonstrated in 3- to 4-month-old infants is not sufficient evidence for such understanding because infants of that age do not associate animals with biological motion cues as provided in point-light displays (Arterberry & Bornstein 2002). The understanding of the object-directedness nature of human actions does not seem well linked to protoconversations either, seeing as this understanding emerges later (6 months) and initially only for reaching actions (Woodward 1998, 2003). In fact, a topic of growing interest and debate revolves around the empirical evidence required to determine when infants understand the act of seeing, as opposed to looking (Poulin-Dubois et al., in press).

Tomasello et al. argue that, around 9 to 10 months of age, infants show some understanding that other people pursue goals – an understanding that coincides with the emergence of triadic engagement (shared goals and perceptions). The evidence is stronger along this line of research, although one can still quibble over the richness of the interpretations provided in some of the studies cited. For example, recent research indicates that infants' ability to distinguish intentional from accidental actions, along with the understanding of failed goals, is an ability that develops significantly between 12 and 18 months of age (Bellagamba & Tomasello 1999; Olineck & Poulin-Dubois 2005). The findings from the "unwilling vs. unable" experiment are intriguing although open to alternative interpretations, such as the presence or absence of hand contact with the object in question.

The final and third level in the ontogeny of shared intentionality involves the understanding that actors can choose among different means (or plans) to achieve a goal. This understanding is apparent at the same time as triadic engagements become collaborative through the emergence of joint intentions and attention (12 to 14 months). Once more, it is my opinion that the developmental sequence described by Tomasello et al. is somewhat too protracted, as data on infants' understanding of planning (or prior intentions) before the age of 24 months are scarce at best (Carpenter et al. 2002). If imitative learning is considered the crowning achievement of animate action understanding, then it would seem critical to document whether infants differentially produce actions demonstrated by human and nonhuman agents (such as computer animations or robots). Preliminary data from my laboratory suggests that infants can perform generalized imitation of actions from demonstrations without a human agent (Poulin-Dubois & St-Pierre, submitted).

The study of atypical cognitive development often sheds a unique light on the mechanisms involved in normal development (Karmiloff-Smith 2002). In the article by Tomasello et al., the authors argue that autistic children show good understanding of human intentional action and perception, though these children do not follow the typical human developmental pathway of social engagement with other persons. In fact, Tomasello et al. show that autistic children's deficits in each of the three types of social engagement bear a striking resemblance to those of great apes. In my opinion, the impaired shared-intentionality pathway better captures the social and communication failure that is at the very core of autistic disorder than the failure to represent mental states such as beliefs (Baron-Cohen 1995). On the other hand, the fact that difficulties in face recognition are common throughout the autism spectrum and that brain activation patterns in adults with autism do not differ for faces and objects are two observations that are difficult to reconcile with the hypothesis that autistic individuals have an intact understanding of people's goals and perceptions (Carver & Dawson 2002; Schultz et al 2000). Although the extent to which autistic children possess cultural learning skills remains to be determined, the case of autism is an interesting one for any evolutionary perspective on human social cognition, seeing as it is a developmental disorder that has a neurological basis in the brain and genetic causes play a major role in its development (Frith 1989).

One line of research that is ignored that might present a challenge for the present proposal concerns characteristics of the mirror-neuron system in humans (Rizzolatti & Craighero 2004). More specifically, the dissociation between intentional action understanding and shared intentionality in autistic individuals seems at odds with the fact that the human mirror-neuron system is involved in action understanding, imitation, and language processing. In conclusion, the target article provides the readers with a good working hypothesis that biological and cultural roots are essential in any effort to unify the evolution and development of human cognition. How this approach fares in handling data from the latest research in developmental cognitive neuroscience is yet to be determined and will surely be an interesting story to follow up on.

Reinterpreting behavior: A human specialization?

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Abstract: Tomasello et al. argue that the "small difference that made a big difference" in the evolution of the human mind was the disposition to share intentions. Chimpanzees are said to understand certain mental states (like intentions), but not share them. We argue that an alternative model is better supported by the data: the capacity to represent mental states (and other unobservable phenomena) is a human specialization that co-evolved with natural language.

Is there a meaningful difference between representing mental states versus representing behavior? This is a pivotal issue, because no one disputes that chimpanzees (or many other species) represent and reason about the behavior of others. Unfortunately, Tomasello et al.'s definition of what it means to *understand intentions* includes the ability to represent the actions associated with achieving a goal. Later, this definition allows them to argue that, because apes exhibit the ability to form complex representations of action, they possess at least part of the ability to understand intentions! As we shall show, this overlooks an alternative possibility: these representational codes evolved separately.

To begin, we note that the experiments they cite in support of the idea that chimpanzees represent intentions are designed in a manner that cannot distinguish between whether they are reasoning about behavior alone, or behavior and mental states (Povinelli & Vonk 2003, 2004; Tomasello et al. 2003a, 2003b). Why? Because the experimental manipulations *presuppose* that the subjects can distinguish between two classes of action (e.g., accidentally dropping a grape versus pulling it back in a taunting manner [see Call et al. 2004]), and once this is granted, then there is no unique causal work left for the purported intention attribution.

To put these empirical issues into proper perspective, consider

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the evolutionary model we have offered (see Povinelli et al. 2000). The *reinterpretation hypothesis* posits that the ancestor of the ape/human group possessed a suite of systems dedicated to representing and reasoning about behavior (detailed in Povinelli & Vonk 2004), but not intentions or other mental states. Further the model posits that, at some point in the evolution of the human lineage (probably coincident with evolution of natural language), a new system for encoding the behavior of self and other in terms of mental states was grafted into these ancestral systems for representing and reasoning about behavior. In modern humans, then, these two systems are now complexly interleaved into each other. Thus, the model stipulates that many of the same invariants in the behavior of others that humans explain in terms of underlying mental states, were discovered and exploited long before we evolved to re-code them in a mentalistic fashion. Furthermore, the model suggests that humans still do both: every time we attribute a mental state, we have already isolated a behavioral abstraction. The reinterpretation hypothesis thus suggests that it is not only *possible* to consider that chimpanzees and other species represent behavior without representing mental states, it suggests that, this is the typical case. Humans are the exception.

In this theoretical light, it is easier to see why the empirical data cited by Tomasello et al. do not demonstrate that apes represent intentions as mental states. Reconsider the unwilling/unable study. Although humans can attribute different intentions in cases where someone intentionally withholds something versus cases where it is accidentally dropped, and although this attribution can be causally implicated in generating aggressive reactions in the first case, but not the second, there is no reason why these reactions need to be mediated by an intention attribution. Even in humans, much of the time they probably are not. Although different intentions do indeed underlie the two actions, the chimpanzee (or human) need not know this to keep track of the behavioral invariances. And because these invariances must be represented anyhow (that is the basis upon which the different intention attributions are purported to be based), then what additional explanatory work does the intention representation perform in explaining the experimental results? As far as we can tell, none. The reinterpretation model suggests why: the ability to represent mental states co-opted the systems for behavioral representation that were already in place.

This issue plagues all experiments cited by Tomasello et al. (see Povinelli & Vonk 2004). For example, the authors describe a series of food-competition experiments to support the claim that chimpanzees "understand that what others see affects what they do." We have already shown in detail why this attribution is unwarranted by using the reasoning just described (Povinelli & Vonk 2003, 2004). Furthermore, empirical findings show that the robust effects of these studies are easily accounted for by nonmentalistic construals of the situation (some as simple as "on the basis of previous experience, don't approach food if it is in the unobstructed path of a dominant individual" [see Karin-D'Arcy & Povinelli 2002, experiments 3 to 6; Povinelli & Vonk 2003, 2004]).

Importantly, the authors overlook other data that have experimentally analyzed how chimpanzees interpret social cues related to "seeing" in simple social situations in which they can request food from one of two caretakers. *Without training*, chimpanzees base their choices on full body orientation (who is facing them) and, *with training*, they rapidly learn to base their choices on the direction of the head or even whether their recipient's eyes are open or closed (Povinelli & Eddy 1996; Reaux et al. 1999). Using slightly different methods these findings have been largely replicated by Tomasello and colleagues (Kaminski et al. 2004). These results suggest that the learned social cues remain subordinate to cues that tend to covary with someone "seeing" them, but have no bearing on "seeing." For example, even after they learn to gesture to the person whose eyes are open (as opposed to the person whose eyes are closed), chimpanzees will nonetheless prefer to gesture to someone whose eyes are closed if that person is facing them, as opposed to someone facing away, but looking (eyes open) over their shoulder toward them! One interpretation of these data is that the behavioral abstractions formed by chimpanzees are essentially postural heuristics that have nothing to do with "seeing" at all.

So, are Tomasello et al. correct that chimpanzees and humans both *understand* certain mental states, but only humans share them? The reinterpretation hypothesis argues that only humans represent mental states at all – and that, in turn, is why we are the only species who shares them. Further, it offers more explanatory power: it explains all the differences that Tomasello et al. catalog between human and great-ape cultures in one evolutionary step. Tomasello et al. require two distinct evolutionary steps: the evolution of the ability to conceive of intentions, followed by the disposition to share them. In the reinterpretation model, sharing such states comes for free, because the original code in which mental states were represented was inextricably embedded in a predominantly social capacity: natural language. And that may be the big difference that made a big difference.

Illusions of intentionality, shared and unshared

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Abstract: Intention, shared or unshared, is based on the presumption of unknowable and unnecessary motives and mental states in ourselves and others.

Until proven otherwise, why not assume that intention does not play a role in human and animal behavior? Although it may seem radical on first hearing, this is actually the conservative position that makes the fewest assumptions. The null position is an antidote to our tendency to presume rational, conscious control over processes that may be unconscious and not require a ghost in the neurological machinery. The argument here is not that we lack consciousness, but that we overestimate the conscious control of behavior and cannot trust its narrative as an explanation of our actions. Proving this proposition is a challenge because it's difficult to think about consciousness and the causes of our behavior, intentional or otherwise. We are misled by an inner voice that generates a reasonable but often fallacious narrative and explanation of our actions, and we use this account to interpret the actions of others. Is the presumption that human cognition "sticks out like an elephant's trunk, a giraffe's neck, a peacock's tail" an illusion in the eye of the beholder? Is the critical level of neurological processing one step removed from the user-friendly but unreliable interface accessible through introspection? That the beam of conscious awareness that illuminates our actions is on only part of the time further complicates the task. Since we are not conscious of our state of unconsciousness, we vastly overestimate the amount of time that we are aware of our own actions, whatever their cause.

My thinking about unconscious control and associated issues of intentionality was shaped by my field studies of the primitive play vocalization of laughter (Provine 2000). When I asked people to explain why they laughed in a particular situation, they would concoct some reasonable fiction about the cause of their behavior – "someone did something funny," "it was something she said," "I wanted to put her at ease." Observations of social context showed that such explanations were typically unfounded. In clinical settings, such post hoc misattributions would be termed *confabulations*, honest but flawed attempts to explain one's actions. How different is our account of intentions?

Subjects in my laughter study also incorrectly presumed that laughing is a choice (intention) and under conscious control, a reason for their confident, if bogus, explanations of their behavior (Provine 2000). But laughing is not a matter of speaking "ha-ha," as we would choose a word in speech. When challenged to laugh on command, most subjects could not do so. In certain, usually

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playful, social contexts, laughter simply happens. However, this lack of voluntary control does not preclude a lawful pattern of behavior. Laughter appears at those places where punctuation would appear in a transcription of a conversation – laughter seldom interrupts the phrase structure of speech. We may say, "I have to go now – ha-ha," but rarely, "I have to – ha-ha – go now." This *punctuation effect* (Provine 1993) is highly reliable and requires the coordination of laughing with the linguistic structure of speech, yet it is performed without conscious awareness of the speaker. Other airway maneuvers such as breathing and coughing punctuate speech and are performed without speaker awareness.

Another challenge to intentionality comes from the contagion of laughter (Provine 1992) and yawning (Provine 1986). Laughter triggers laughter and yawning triggers yawning in observers. In neither case is the contagious act an intention of the observer – it just happens in the presence of the appropriate stimulus. Before explaining these acts away as special cases, consider their similarity to the replication of facial expressions by neonates (Meltzoff & Moore 1977; Provine 1989a; 1989b), a phenomenon reported in terms of the higher cognitive process of imitation and to acts that may be mediated by so-called "mirror neurons" that have been implicated in imitative behaviors and mental state attribution (Arbib et al 2000; Wohlschläger & Bekkering 2002).

The discovery of lawful but unconsciously controlled laughter and yawning led me to consider the generality of this situation to other kinds of behavior. Do we go through life listening to an inner voice that provides similar confabulations about our motives? Are essential details of the neurological process governing human behavior inaccessible to introspection? Can the question of animal consciousness be stood on its head and treated more parsimoniously? Instead of considering whether other animals are conscious, or have a different or lesser consciousness than our own, should we question whether our behavior is under no more conscious control than theirs?

The complex social order of bees, ants, and termites documents what can be achieved with little, if any, conscious control as we think of it. Is intelligent behavior a sign of conscious control? What kinds of tasks require consciousness? In the spirit of Julian Jaynes (1976), I suggest a scientific agenda that pursues an often counterintuitive path, asking hard questions about the role, evolution, and development of consciousness and the associated role of intention. Higher-order cognitive processes should not be tacitly assumed and, when suggested, must be expected to earn their keep. Tomasello et al. do a good job of operationalizing complex tasks and using them in cross-species comparisons. I do not challenge their methods or behavioral results but urge a conservative stance concerning how we talk about and explain the actions of animal minds, including our own.

Humans evolved to become *Homo negotiatus* . . . the rest followed

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Abstract: Social animals need to share space and resources, whether sexual partners, parents, or food. Humans, however, are unique in the way they share as they evolved to become *Homo negotiatus*; a species that is prone to bargain and to dispute the value of things until some agreement is reached. This evolution had far-reaching consequences on the specific makeup of human psychology – a psychology that has for trademark a compulsive preoccupation with the self in relation to others. I propose that the understanding and sharing of intentions are probably the consequences of such evolution, and not its origins.

We evolved to become *Homo negotiatus*, a species keen to count and compare. It is a species that takes advantage or gets even not only by taking, but also by giving. That does not make *Homo negotiatus* a nicer, kinder species compared with other animal species. Obviously not. It does not mean either that close primate relatives do not show some precursor signs of sharing by negotiation (de Waal 1982, 1996).

However, as pointed by the classic anthropological work of Mauss (1967), human societies seem particularly keen to hold at their core the propensity to offer gifts with the explicit motive of strengthening social ties among its members. Gifts allow for the maintenance of social ties over time, the guarantee of a social debt in a society that holds reciprocation as a core value. Mauss showed that gift giving and reciprocation are indeed an organizing core of many small society cultures all over the world. It appears to be a human universal.

There are many plausible stories as to why humans evolved to become *Homo negotiatus*. One story is that the combination of food surplus, food storage, and greater density of group living triggered profound changes in the way humans shared their resources (Diamond 1997). From coercive dominance (the physically more powerful gets the lion's share principle), humans were channeled to engage in actual trading and complex reciprocation via gifts and other bartering chips. In this new way of sharing, the most prestigious and richer individuals became the rulers, getting the lion's share by giving and trading favors, not only by forceful coercion.

Favorable environmental (e.g., climatic) circumstances, technological progress, or any other causes leading to food surplus could have triggered a host of changes in the life of our ancestors, including transactions based on shared values, the birth of bartering, and ultimately the establishment of explicit rules and trade regulations. It is only in recent time (maybe 10 to 15 thousand years) that public (external) memory systems such as symbolic tallying to record current and past transactions seem to have emerged. Such emergence could possibly have ratcheted up a host of other cultural artifacts, including complex writing systems by which the oral tradition articulating the memory of shared values became objectified (externalized) via public documents and decrees. The emergence of such inventions had a formidable, exponential impact on how we coexist and share as a species.

Regardless of the plausibility of such an account, the fact is that we have evolved to become *Homo negotiatus*, not only relating to one another by ways of forceful and instinctive reactions, but also by ways of seduction and lengthy intersubjective negotiation. Humans seem to find particular comfort and reassurance in actively aligning their own experiences with the experiences of others. This does not mean that intersubjectivity is a uniquely human trait. All group-living animals share experiences, all prone to emotional contagion. They alarm one another, fly together in the face of danger, and bunch up to fight back predators. However, humans have the special inclination to probe actively and seek for intersubjective agreement.

Humans have the insatiable need to feel and understand the same as others and, if that is not the case, they attempt by any means to reestablish any lost equilibrium with peers. This process is particularly evident in human mother and infant interactions that are universally characterized by complex affective mirroring and emotional coregulations (Gergely & Watson 1999; Rochat 2001; Stern 1985).

Learning to agree on the value of things by ways of negotiation and reciprocation (what all human children have to do in order to behave adaptively in the culture of their parents) entails the development of specific psychological capacities. These capacities are what set humans apart from any other species. It is the privilege of developmental researchers to witness how these capacities emerge in ontogeny.

Aside from the capacity to understand and share intentions that would presumably form the origins of cultural cognition (Tomasello et al.), I would like to suggest that one of the necessary building block of *Homo negotiatus* is first and probably foremost a unique sense of self. A sense of self that is evaluative in relation to others.

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In ontogeny, the first signs of self-preoccupation and self–other compulsive comparison become evident by the middle of the second year, when children start to show not only explicit self-recognition (Lewis & Ramsey 2005), but also unmistakable signs of embarrassment in front of mirrors (see Rochat, 2003, for a developmental account of emerging coawareness). By their third birthday, children express pride, shame, and other secondary or evaluative emotions (Kagan 1981; Lewis 1992). By the time children start to blush, they also begin to lie. They edit and cover up truth to keep face in relation to others in potentially embarrassing circumstances (Lewis et al. 1989; Polak & Harris 1999).

In his seminal work comparing the expression of emotions in man and animals, Darwin (1965) viewed shyness (embarrassment) as a precursor of blushing. He witnessed blushing in his son at around 3 years and shyness months earlier, pointing to the fact that blushing causes the selective crimsoning of the face, precisely the region of the body that is most visible and attended by others. It is the face that is typically and desperately covered in bouts of embarrassment when feelings are exposed. Following Darwin, this is a unique product of human evolution. It is also the expression of a unique psychological process: the never-ending process of intersubjective negotiation by ways of active self-presentation.

Only humans engage, at least to the extent they do, in self-editing and self-advertising via, for example, body adornments and alterations (e.g., plastic surgery, tattoos, piercing, and makeups). These practices are pervasive across ancient cultures – for example, some 4000 years ago in ancient Egypt (Bianchi 1988). The well-preserved 5,000-year-old frozen body of the "Iceman" found a few years ago in the Austrian Alps shows, aside from an arrow wound, deliberate symbolic scaring and tattoos (Fowler 2001). Even older human remains of Pleistocene Australian aborigines (12,000-year-olds and up) suggest deliberate body alteration, in particular forced skull elongation (Brown 1981). All that is part of the basic human need to affiliate. They are signs of deliberate acts of self-presentation and therefore the expression of active, reciprocal negotiation of values and affective experiences with others.

My intuition is that, in evolution, the motivation to negotiate and reciprocate preceded humans' unique ability to understand and share intentions. In an analogous way, in ontogeny, the need to reciprocate is a necessary condition to the emergence of theories of mind. New, more sophisticated understandings of the self and of others emerge from the primary motivation of finding some agreement on the values of all things: a universal trademark of human cultures.

Distinctive human social motivations in a game-theoretic framework

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Abstract: I discuss implications of Tomasello et al's hypothesis that humans exhibit distinctive collective intentionality for game-theoretic approaches to modeling human evolution. Representing the hypothesis game-theoretically forces a question about whether it implies only distinctively human motivations or both distinctive motivations and distinctive cognitive capacities for representation of intentions. I also note that the hypothesis explains uniquely human ideological conflict and invites game-theoretic modeling of this.

The perspective on cultural cognition urged by Tomasello et al. is persuasive in light of the evidence they cite and constitutes a significant advance in our understanding of what is ethologically and developmentally distinctive about *Homo sapiens* in comparison with other apes. *Homo sapiens* is not just, or even mainly, a uniquely adept mind reader; she is, more fundamentally, an animal that collectively constructs the special cultural entities we call *people* in the course of coordinating around joint projects that have joint-ness itself, and not merely the achievement of environmental changes, as part of their point. In this commentary, I discuss some implications of this perspective for the ways in which we formally model human evolution in game theory. A central purpose of formal modeling is of course to discipline thought. It is thus encouraging that asking questions about the formal representation of Tomasello et al.'s thesis invites some further questions about refinements to that thesis on which they are not fully clear.

In recent work (Ross 2004; 2005; forthcoming), I have argued that, in constructing evolutionary game-theoretic models of human history, it is necessary to mark certain sorts of *ontological phase shifts*, with respect to both types of agents and types of games, in our formalism. First-generation evolutionary psychology obscured this. In particular, approaches such as those collected in Barkow et al. (1992) encouraged conception of modern people as agents with utility functions evolved for a Pleistocene ancestral environment trying to optimize under novel circumstances. I have argued, in contrast, that human organisms are under pressure from birth to narrate distinctive *selves* into existence for the sake of stabilizing behavioral expectations – for others and for themselves – so as to facilitate coordination. Since these selves have different utility functions from *both* ancestral hominids and pre-enculturated infants, they play a range of games drawn from a different selection space. Nevertheless, there must be constraining relations among the games played by early hominids, modern infants, and enculturated people. (The evolutionary perspective tells us there is information flow of a systematic sort among the instances of these kinds of games.) My work has aimed at modeling these relations without reducing one class of games to another. Summarizing maximally broadly, a modern infant's utility function is an output of a class of evolutionary games G'' played among lineages. Infants are enculturated through play of a class of repeated games G' with adults. G'-level games turn infants into new agents with new utility functions. These agents play classical games of class G with one another, as described by economists and sociologists. Then statistical distributions of adult human behavioral patterns should be simultaneously consistent with short-run equilibrium conditions governing G-level strategies, medium-run equilibrium conditions governing G'-level strategies, and long-run equilibrium conditions governing G''-level strategies. Binmore (1998) has advocated a similar picture less explicitly. The contrast between it and models of the Barkow et al. type may be glossed thus: according to first-generation views in evolutionary psychology, modern people can be modeled as generic apes with "social wraparounds"; according to Binmore and me,[1] this is seriously misleading.

The hypothesis defended by Tomasello et al. lends itself to formalization in the framework I have urged. Humans' most recent common ancestors with chimpanzees and bonobos should be modeled as products of G''-level games that have (at least) two long-run basins of attraction: a basin in which G'-level players receive no utility from cooperation for its own sake (that is, over and above utility from environmental contingencies induced by cooperation) and a basin in which cooperation for its own sake *is* a source of utility. Contemporary chimps, both infants and adults, play games drawn from the first basin; contemporary people play games drawn from the second. Nonhuman apes do not play G-level games.

Expressing their hypothesis in this modeling framework raises a question for Tomasello et al. They suggest that people share cognitive capacities for representation of intentional structures with other apes, but are distinguished from them by a motivation to converge on what could be called "collective" utility functions. They also survey evidence that people, but not other apes, represent intentions "dialogically." Now, in the game-theoretic framework I have described, differences in cognitive skill sets are relevant to available strategy spaces in games, but, unlike differences

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in utility functions, do not necessarily imply re-individuation of games themselves. Thus, addressing the point at the level of the phenomena, the fact that chimps do not use dialogic representations of intentionality may just result from the fact that they are not motivated to do so, rather than from limitations in their cognitive architecture. None of the experiments discussed by Tomasello et al. seem to provide a basis for discriminating between the hypotheses that (1) humans retain the generic ape cognitive architecture with modified utility functions, and (2) motivational adaptations in hominids led to cognitive adaptations in them. For example (citing a case they discuss), does Kanzi show sharply limited linguistic skills because he lacks the relevant Chomskyan module, or because he is interested only in getting objects he wants from people and has no interest in negotiating meaning? Tomasello et al.'s argument might motivate design of experimental protocols that could discriminate between these hypotheses, perhaps by putting language-trained chimps in situations where they can satisfy their first-order desires only by negotiating meanings. This would of course require some ingenuity on the part of the experiment designer.

In closing, I note one aspect of human behavioral distinctiveness that Tomasello et al.'s hypothesis explains, but that they do not mention. As far as we know, only people engage in violence in order to try to eliminate beliefs that diverge from their own. There is a long tradition of explaining ideological conflict by reference to conflict over material resources. This cannot explain why there are no homologues to such behavior in other intelligent social animals. Thanks to Tomasello et al., we can advance a better explanation: only people care nonderivatively about not only who gets what, but about whether others want the same things as they do. Modeling the evolutionary dynamics of these sorts of interacting motivations is a compelling new challenge for game theorists.

NOTE

1. Clark (2002), Dennett (2003), and Sterelny (2004) all provide supporting philosophical arguments for this view.

Why not chimpanzees, lions, and hyenas too?

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Abstract: Examples are cited of group hunting in chimpanzees, lions, and hyenas consistent with evidence for intentionality, organization, and coordination. These challenge the claim for shared intentionality as uniquely human. Even when rarely performed in this way, the significance of such behaviors should not be minimized, especially if this level of "intelligent" action emerges spontaneously in the wild.

The target article sharpens the terms of an ancient debate – What distinguishes the modern human *Homo sapiens sapiens* from *all* other animals? – by acknowledging that species such as the chimpanzee *Pan troglodytes* possess the cognitive complexity for social strategizing, sensitivity to the intentional actions of others, and glimmers of a theory of mind (Dennett, 1983; Povinelli 1993; Tomasello & Call 1997). The authors also acknowledge the prevalence of animal *intentionality* when behavior is consistent with the ability to choose a plan of action and stay with this plan to achieve a predetermined goal. Instead, they place the animal–human divide in the realm of *shared mental states*, and specifically in the ability of humans to use *shared intentionality* (hereafter SI). This is expressed in "collaborative activities with shared goals and intentions," consistent with "shared psychological states" and unique forms of "cognitive representation." Even if some animal species are capable of understanding the goals, intentions, and perceptions of others, only the human possesses the motivation to share these things in interaction with others.

Since animals are being compared with humans, the argument hinges on documenting observable actions (see Tomasello et al., Fig. 1) and *specifying testable behavioral criteria* for making inferences about underlying SI. This commentary asks whether SI might underlie the apparent convergence between the performances of humans and some animals when *individuals cooperate by coordinating actions for shared outcomes*. Intuitively, *cooperative coordination* (hereafter CC) offers an obvious place to search for SI because individuals develop conjoint actions for shared outcomes based on using each other's behaviors and locations. We have modeled this in rats *Rattus norvegicus* (Schuster 2002; Schuster & Perelberg 2004). But the argument is better made from three examples of CC expressed spontaneously in the wild without the aid of behavioral engineering. All are in the context of group hunting.

In the chimpanzee *Pan troglodytes*, hunts have been described and filmed that are spontaneous and highly organized: a group first gathers and then simultaneously fans out in search for a victim while reducing the chances of detection by avoiding vocalizations and using slow and careful steps to minimize noise (Boesch & Boesch 1989; Mitani & Watts 2001). There is also a division of labor based on roles that was characterized by Boesch and Boesch (1989) as *collaboration*: a "blocker;" a "chaser;" an "ambusher;" and others remaining on the ground to track the hunt and intercept a fleeing target if the opportunity arises. Chimpanzees behave similarly in group territorial "warfare" against members of neighboring groups (Boehm 1992; Watts & Mitani 2001).

Tomasello et al. reject the foregoing as evidence for SI by suggesting that individuals are indeed *acting together* but not collaborating in a way that provides undeniable evidence for joint intentions and coordinated plans. Instead, each participant is said to be performing its own particular role as a response to the locations and behaviors of others and the momentary "state of the chase." Hunts are thereby characterized as helter-skelter running in all directions, with the lucky hunters opportunistically making a kill if an unfortunate victim comes their way. Stanford et al. (1994) suggest that the hunts observed at the Gombe Reserve site are mostly of this type.

Have Boesch and Boesch (1989) exaggerated the levels of intentionality, spontaneity, and organization? Or, as seems more likely, chimpanzee hunts may run the gamut from random and disorganized to deliberate and planned, with the likelihood of each varying both across populations and within populations but across seasons and locations. If so, it would be misleading if the examples of opportunistic and random attacks were used to cancel out the significance of those instances *when chimpanzees do engage in organized, intentional group attacks*. Why would we expect chimpanzees – or any other species, including our own – to rely exclusively on the most complex tactics if success is achievable by lesser means? Moreover, intelligent, creative action is almost by definition limited to *some* members of a population and then only on those limited occasions when *automaticity* in actions and thoughts does not work (Bargh & Chartrand 1999). This variability is reflected in the current criteria for publishing research on themes linked to animal intelligence – political scheming, tool use, deception, or theory of mind – where data may be cited from only those few subjects that exhibit the phenomenon or even from $n = 1$ (e.g., see Premack & Woodruff 1978). The hypothesis of SI in chimpanzees should not be rejected even if organized and intentional hunts are rare.

More interesting for SI in animals is the performance of group hunting in less "cognitively endowed" mammals such as the African lion *Panthera leo* and the spotted hyena *Crocuta crocuta*. The overall picture resembles that in chimpanzees. Schaller (1972) noted that lions are usually opportunistic hunters capable of chasing after prey that suddenly appears, whether acting either alone or in groups that happen to be there. But he added,

> [O]n 29 occasions lionesses encircled prey, sometimes by detouring far to one side. . . . The other lions waited during the flanking movement

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> as if in anticipation of prey fleeing in their direction. . . . During such hunts lions integrated their actions solely by observing each other's posture and movement; no sounds were used nor were facial expressions employed which, at any rate, would not have been useful at night. *Encircling implies that lions are aware of the consequences of their actions in relation both to other group members and to the prey*. (pp. 250–51, italics mine)

The same behavior was observed by Griffin (1984, pp. 85–87) and studied in detail by Stander (1992).

The hypothesis of SI would be strengthened if animals spontaneously assemble into groups whose size is related to differences in the prey that are going to be hunted and *before the prey have been spotted*. In lions, for example, the larger males are more likely to participate in hunts when the prey is also large, for example, buffalo *Syncerus caffer* or zebra *Equus burchelli* (Schaller 1972). Kruuk (1972) explicitly noted this evidence for group intentionality in the spotted hyena:

> [T]he differences in numbers of hyenas setting out are often apparent long before the hyenas have sighted a quarry; when hyenas are seen in a pack, even if there are no herbivores near, one can predict with a fair degree of certainty that they will eventually hunt zebra, even if this means walking for miles through herds of wildebeest. *This means that hyenas set out to hunt a certain kind of prey to the exclusion of others*. . . . the hyena's hunting methods are very well adapted to the requirements of catching different kinds of prey; the antipredator mechanisms of wildebeest and zebra are so unlike each other that they call for very different hunting action. If the hunting formation has to be taken up before meeting the adversary this would have the consequence of causing hyenas to concentrate on one kind of prey only. (pp. 201–2, italics mine)

It may not be coincidental that behaviors consistent with SI are shown by hyenas, lions, and chimpanzees when engaging in group hunting and aggression that, like so many human behaviors, are structured around individuals using one another to coordinate behaviors for shared outcomes. SI may be more obvious in humans because its widespread use – in culture-based activities such as science, art, music, and religion – was facilitated by language and culture by a process of *exaptation*. In sensu Rozin (1976) and Mithen (1996), it is only in modern humans that SI becomes conspicuous because it can be applied to activities for which it was not originally designed. The flip side is that animals exhibit only minimal SI because it is *not* an open and accessible program but one that is restricted only to task-specific contexts such as group hunting and group territoriality for which it evolved. But the possibility for a limited expression of context-specific SI in animals is an alternative worth considering, and one that may shed some light on its origins.

Baby steps on the path to understanding intentions

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Abstract: Tomasello et al. lay out a three-step ontogenetic pathway for infants' understanding of intentional action. By this account, before 9 months, infants do not understand actions as being goal directed. However, we caution against drawing strong conclusions from negative findings, and, based on recent findings, propose that a key aspect of goal knowledge is present well before 9 months.

To describe the development of infants' understanding of intentions, Tomasello et al. lay out a three-step ontogenetic pathway. Step 1: Early in the first year, infants understand that others' actions are spontaneously produced. Step 2: Beginning around 9 months, infants understand others' actions as driven by internally represented goals. According to Tomasello et al.'s definition of *goal*, this means that infants know that agents monitor the outcomes of their attempts and persist in their efforts when unsuccessful. Step 3: By 12 to 14 months, infants understand others' choice of plans in order to achieve goals. Frameworks like this one are invaluable to the field because they provide the foundation for understanding developmental change. For this reason, it is critical that the framework be right. We suggest one caveat and one revision to Tomasello et al.'s framework.

We take issue with the evidence used to argue that infants do not understand the persistent nature of goal-directed activity before 9 months. To support this claim, Tomasello et al. cite two studies. One is the habituation work by Csibra et al. (1999), in which 9- and 12-month-olds, but not 6-month-olds, responded with longer looks when a computer-animated dot moved in an "irrational" way. The other is work by Behne et al. (2005), which revealed that 9- and 12-month-olds, but not 6-month-olds, communicated more impatience when an experimenter was unwilling to give them a toy than when she was unable to do so.

The claim that these failures of 6-month-olds indicate a lack of goal understanding is problematic because it relies on negative evidence. Both studies required infants to interpret complex or abstract physical constraints and their implications for the agent's ability to attain a goal. As Csibra et al. (1999) pointed out, 6-month-olds may understand goal-directed action, but be unable to infer the physical constraints that make an action rational or a goal unattainable in these experiments. A further concern regarding Behne et al.'s study is that even if the 6-month-olds understood the physical constraints involved, they probably lacked the communicative competence to express their frustration.

Given these concerns, we are left with three possibilities for what 6-month-olds understand about agents' pursuit of goals. One possibility, consistent with Tomasello et al., is that these infants entirely lack this understanding. A second possibility is that this understanding is fully developed by 6 months. Neither possibility can be supported until the appropriate studies have been conducted.

A third possibility, and the one we think most likely, is that 6-month-olds have some basic understanding of goal-directed action that is less developed than at 9 months, but more developed than is suggested by Tomasello et al.'s first step. Well before 9 months, infants understand agents' actions as organized by the agent's relation to an external object. This conclusion is supported by habituation experiments showing that infants display selective and robust novelty responses to changes in the relation between a person and the object at which her actions are directed (Sommerville et al. 2005; Woodward 1998, 1999, 2003, 2005).

Tomasello et al. gloss these findings as evidence that infants expect people to reach for the same object again and again. We do not believe this is the correct interpretation. For one, it is not clear that such an expectation could be derived from experience: people do not normally reach for the same object repeatedly. Moreover, our habituation method is a measure of infants' novelty detection rather than a violation-of-expectation paradigm. Rather than viewing apparently impossible events, infants in these studies saw events that differed on one of two conceptually important dimensions, and their novelty responses indicated which dimension was central to their event representation.

Infants represent meaningful human actions as object directed. They do not represent the motions of inanimate objects (Jovanovic et al. 2002; Woodward 1998) or other human movements in this way (Woodward 1999). Thus these findings do not reflect a general tendency to encode spatial relations, but rather a specific propensity to encode people's actions in terms of agent–object relations. Infants do this for concrete actions, like grasping, early in the first year (Sommerville et al., in press; Woodward 1998), and for abstract ones, like looking, by the end of the first year (Phillips et al. 2002; Sodian & Thoermer 2004; Woodward 2003). Moreover, consistent with Tomasello et al.'s suggestion that infants' own actions structure their emerging concepts of intention, infants'

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own experiences as intentional agents correlate with and affect their propensity to represent others' actions as object directed (Sommerville & Woodward, 2005; Sommerville et al., in press; Woodward, in press; Woodward & Guajardo 2002).

Therefore, we propose a step intermediate to Tomasello et al.'s steps 1 and 2: early in the first year, infants represent some actions as being object directed. They can then recruit these representations to make more complex inferences, including predictions about what an agent will do in future situations; that is, infants might begin by realizing that certain actions are organized with respect to external objects and then learn about the relations between actions like looking, opening, and reaching. These relations in turn could support Tomasello et al.'s second step, the insight that agents persist to attain goals while monitoring the success of their efforts.

It is extremely useful to lay out an ontogenetic map of cognitive development, as Tomasello et al. have done. However, it is important to be cautious in drawing conclusions about where infants of a given age are on this ontogenetic path and to consider possible intermediary steps along the way. It is a big jump from Tomasello et al.'s step 1 (nothing in the head) to step 2 (internally represented goals and monitoring systems) – such a big jump, in fact, that it might be tempting to conclude that step 2 emerges of whole cloth from innate specifications. Like Tomasello et al., we believe it is important to go beyond labeling cognitive skills as *innate*. Their ontogenetic pathway positions us to investigate how an understanding of goal-directed action could be built in the course of early conceptual development. Our findings elucidate a baby step on the way to this foundational insight.

Lack of motivation to share intentions: Primary deficit in autism?

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Abstract: We review evidence regarding Tomasello et al.'s proposal that individuals with autism understand intentions but fail socially because of a lack of motivation to share intentions. We argue that they are often motivated to understand others but fail because they lack the perceptual integration skills that are needed to apply their basically intact theory of mind skills in complex social situations.

Tomasello et al. state that all individuals with autism have clear deficits in the development of collaborative engagements with others, although at least some understand actions as goal directed if not fully intentional. This discrepancy between intact intentional understanding and defective social performance holds true also at higher levels of theory of mind (TOM): A subgroup of high-functioning individuals with autism show no deficits in complex TOM skills, as assessed by second-order belief tasks (Ellis & Hunter 1999), and in recognizing basic emotions in other people's faces (Baron-Cohen et al. 1997; Roeyers et al. 2001). However, in their everyday functioning, they seem unable to use these mind-reading abilities satisfactorily. Hence, a distinction must be made between TOM functioning in a test setting and in everyday life. In test situations, individuals with autism spectrum disorder (ASD) have time to use compensatory strategies that they cannot use in everyday-life situations. This may also explain why general intelligence strongly affects task performance and why different studies comparing individuals with ASD and control groups have obtained conflicting results (see also Brent et al. 2004).

Tomasello et al. propose that a lack of motivation to share intentions with others is the main cause of the observed discrepancy between test situations and everyday life. Further analysis of the basic mechanisms behind this motivational theory of ASD is necessary, otherwise it remains descriptive instead of explanatory. So, what is the underlying nature of this deficit? Tomasello et al. acknowledge that our knowledge of the putatively basic human motivation to share intentions with others is limited. The inability to make appropriate social judgments about faces in both individuals with ASD and individuals with bilateral amygdala damage suggests that amygdala dysfunction impairs the ability to link social stimuli with their social meaning and may explain a lack of social interest (Adolphs et al. 2001; Grelotti et al. 2002; Schultz et al. 2000).

However, most children with high-functioning ASD have an intact social interest and initiate social contact as frequently as other children do (Frith 1989, 2003). So, if the core deficit lies in the area of social motivation, it cannot be a lack of social interest in general, but a more specific aspect, for example, lack of interest in other people's mental states. One such form of social interest is joint attention (or joint perception in Tomasello et al.'s terminology), the coordination or sharing of attentive activities such as gaze following and looking where someone is pointing – all essential activities for so-called triadic engagement. Several studies have shown that children with ASD show deficits in the development of joint attention, especially in spontaneously initiating joint attention with a social partner (Mundy et al. 1994; Sigman & Ruskin 1999). There is some evidence that the degree of joint attention earlier in development correlates with the degree of TOM later in development in control children but not in children with ASD (Warreyn et al. 2004). In autistic children, the degree of joint attention correlates negatively with the severity of all the core symptoms of autism (Charman 2003) and with language ability (Dawson et al. 2004), but this correlation does not establish a causal link between deficient joint attention and ASD, nor with its hypothesized deficient motivation to share intentions.

Going one step further, we raise doubts about the existence of this deficiency in social motivation itself. Clinical experience shows that at least some high-functioning adults with ASD have a strong – sometimes even fanatical – interest in what other people feel or think: They spend a great deal of time trying to infer what a certain behavior or utterance means. Often they describe this uncertainty about what is going on in other people's minds as the greatest stressor in their lives. These adults clearly do not suffer from a lack of motivation to share things psychologically with others, but rather from the conflict between their desire to understand others and their inability to do so adequately. Of course, this argument does not exclude that children with ASD lack the motivation to share intentions at a developmentally earlier stage, but the key question remains: Why do adults with ASD who have the skills to read other people's minds in a test situation, and are motivated to do so in daily life, still fail to mind read in natural social interactions? In other words, if motivation is not (or no longer) the problem, what is?

One hypothesis is that individuals with ASD lack the perceptual prerequisites to apply their TOM in complex social situations. A certain level of perceptual integration is necessary to infer correctly what another person is feeling. For example, a smile taken in isolation could mean anything: Only by integrating perceptions of how the person is looking, what he is doing, what his voice sounds like, and the social context, with knowledge about previous experiences with this person, does it become clear whether this person is just greeting you kindly or making fun of you. Even at the basic level of sharing intentions, representations of the intention of the subject need to be integrated with representations of the intention of the other person. Uta Frith (1989) was the first to draw attention to this deficient integration in children with ASD

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in the so-called *weak central coherence* hypothesis (Frith & Happé 1994). Unfortunately, the empirical evidence for this theory is equivocal (Brosnan et al. 2004; Mottron et al. 2003; Plaisted et al. 1999; Ropar & Mitchell 2001), and the correlations between tests of weak central coherence and TOM tests are low (Jarrold et al. 2000; Morgan, et al. 2003). One reason is that this hypothesis lacks specificity: It may apply to all kinds of information integration, from low-level perceptual processing (e.g., perceptual grouping and Gestalt formation) to cross-modal perceptual integration and to more semantic forms of integration. Another reason may be that TOM tests do not require fast and complex integration. Despite these limitations, this perceptual integration deficit hypothesis offers a promising alternative to Tomasello et al.'s motivational explanation.

In summary, we think it is premature to explain autism by the theory of shared intentionality: The available empirical evidence suggests alternative mechanisms. In any event, it is very worthwhile to reassess all the putative modules of the theory of shared intentionality, specifying developmental pathways amongst them, and testing these in typically developing individuals as well as in individuals with developmental disorders such as ASD. Such an extensive research program is really needed before bringing evolutionary anthropology (EVA) to autism and development of abilities of the mind (ADAM) will fructify.

"Einstein's baby" could infer intentionality

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Abstract: Some implications of Tomasello et al.'s theory derive from incorporating a variant of a common assumption that humans are biologically adapted to take an intentional stance in relation to conspecifics. I argue that, rather than being cued, intentions and other dispositional states may be inferred logically from an evolved commitment to determinism and evidence of state-dependent behavior.

Tomasello et al. propose a bold theory of how "shared intentionality" arises within human ontogeny and provides the basis for other capacities that are also apparently unique to humans. The major novelty of this proposal is in the details of how and why an infant's attribution of intention to another person develops to sharing an intention with another person and ultimately to incorporating a representation of the other's intention within his own. I have no quarrel with the fascinating theory of transition in their control-systems model, but I am concerned with the authors' explicit claim of how the system gets started.

The authors propose that infant humans and other primates come to view conspecifics as intentional agents by virtue of having an innate bias to do so and by experiencing intentional states within themselves. Others have made similar assumptions about bias. For example, in his book *Descartes' Baby* (2004), Bloom proposes that humans are endowed with a dualistic bias to view physical objects as subject to external causes and animate objects as subject to internal causes (e.g., intentional states). Because these internal causes are not visible, it has been commonly assumed that they are brought into play cognitively by stimulus triggers (e.g., animacy, humanoid features of face or hand) that have coevolved with the advantageous strategy of the "intentional stance" that they elicit (Dennett 1971, 1987).

This view may be right, but it is not as obviously right as the authors appear to assume, as when they say "understanding actions as goal directed is a biological adaptation" and "understanding intentional action depends on species-typical social interactions early in ontogeny" (sect. 5.2, para. 4). If these starting assumptions are wrong, that need not affect much of their novel view of ontogeny. However, some implications of their theory will be at risk regarding the evolutionary story and the perspective on autism. Consider then, the following alternative for getting the system started.

A large body of evidence on human-infant learning is at least consistent with an assumption of an endowed capacity to analyze and adapt to the causal contingencies of a determinant world (Tarabulsy et al. 1996). Let us assume that this broadly adaptive capacity evolved to a form of what might be called the *determinist's stance*. Two central features of this stance are that all events are the effects of causal laws ("God does not play dice"), and causal laws are complete and universal (not sometimes true and sometimes false or somewhere true and elsewhere false). Even from the perspective of probabilistic determinism, all things being equal, if a sufficient cause occurs, then the effect should occur with specified probability over repeated instances (e.g., not 0.8 sometimes and 0.2 at other times).

A notable feature of good laws from the determinist stance is that they are not symmetrical in the relation of cause and effect. With a good law, if you know the causal context is complete, then you know the exact effect that will occur (or, in probabilistic determinism, the probability of that effect). But the reverse is not entailed. Alternative causes may exist for a specific kind of effect. In such cases, knowing that a specific effect has occurred leaves open the question of which of the alternative causes was the determinant.

As I note elsewhere (Watson, 2005), historical criteria for purposive behavior have referred to behavioral persistence and rationality (as do Tomasello et al.) but also to *equi-finality* – an agent producing an equivalent outcome across varying situations by making necessary changes in the instrumental behavior (Heider 1958). Equi-finality provides statistical evidence for the inference of goal-directedness versus coincidence. Stronger still, the determinist stance will provide a deductive implication from evidence of *equi-origin* – an agent behaving differently over instances of equivalent situations. To the extent the situations are held to be equivalent, a determinist will be forced to introduce a dispositional difference in conception of the actor's state (Fig. 1). A deterministic account of the actor's varying behavior requires the cause to reside either in the situation, the actor, or both. If the situations are equivalent, the actor cannot be (as per negation of disjunction – A or B, not B, therefore A). It is perhaps worth noting that the so called cue of animacy is usually presented in a manner that provides evidence of equi-origin (i.e., the animate object changes behavior in an otherwise constant situation).

The idea that very young humans might respond to logical implication is not new. Gopnik et al. (2004) are explicit in the assumption that preschool children are, at least unconsciously, sensitive to logical constraint in their studies of how *causal power* is inferred. More recently, they too have considered the effect of a commitment to determinism as a means of inferring hidden physical causes (Schulz & Gopnick, forthcoming). Piaget (1954) framed the infant's capacity to pass stage IV of object permanence

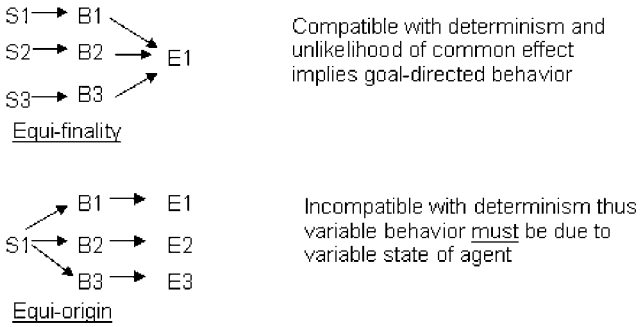

Figure 1 (Watson). Logical impact of observed equi-finality or equi-origin of an agent's behavior (B) across situations (S) in relation to effects (E) of that behavior.

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(around 8 months of age) in terms of underlying capacities for representation and deduction. The contemporary research on physical and social knowledge in infants (e.g., solidity, gravity, numerical object relations, and implications of desire) that relies on manipulation of expectancy (e.g., use of the habituation/recovery method) is at least implicitly assuming logical processing on the part of the infant. Csibra et al. (1999) argue for a view of young infants employing "principle based" reasoning about rational action when engaged in the teleological or intentional stance.

Implications. Contrary to the simulationist perspective favored by the authors, infants (as logical determinists) may conceivably use evidence of equi-finality and equi-origin to provide a causal understanding of others as intentional. Indeed, it is conceivable that they may do this in coming to understand there own intentionality. If infants can infer mental state variation by virtue of a primitive determinist stance and some primitive capacity for causal logic, then these factors should be examined for phylogenetic and ontogenetic differences. If comparative analysis of a commitment to determinism is as challenging as analysis of inference (Watson et al. 2001), it will not be an easy task.

Triadic bodily mimesis is the difference

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Abstract: We find that the nature and origin of the proposed "dialogical cognitive representations" in the target article is not sufficiently clear. Our proposal is that (triadic) *bodily mimesis* and in particular *mimetic schemas* – prelinguistic representational, intersubjective structures, emerging through imitation but subsequently interiorized – can provide the necessary link between private sensory-motor experience and public language. In particular, we argue that shared intentionality requires triadic mimesis.

Tomasello et al. claim that the crucial difference between human beings and apes is "an adaptation for participating in collaborative activities involving shared intentionality" (sect. 6, para. 2), as a result of which human children develop "dialogic cognitive representations." We are sympathetic to this proposal but do not find the nature and the origin of these representations sufficiently clear. Tomasello et al. do not state whether they have an expression-content structure and, if so, whether they are based on language itself, making the account somewhat circular. As for their emergence, it is much too vague to suggest that they are "in some way internalized in Vygotskyan fashion" (sect. 5.2, para. 11).

As an alternative, we suggest that a crucial difference between us and other animals is our advanced capacity for *bodily mimesis*, in particular in its relation to the formation of the *sign function* (Sonesson 1989). Departing from the work of Piaget (1948) and Donald (1991, 2001), we have developed an account of how bodily mimesis provides a "missing link" in both human evolution and child development (Zlatev in press; Zlatev et al., 2005) which we here suggest as an alternative to Tomasello et al.'s account.

Bodily mimesis is based on the ability to match the largely proprioceptively defined *body schema* and more multimodal and consciously accessible *body image* (Gallagher 1995) with perceptions from other modalities. We propose a four-stage model of the development of bodily mimesis that we call the *mimesis hierarchy* and argue that it can be applied to ontogeny as well as phylogeny.

The simplest form, *protomimesis*, involves "body matching," but lacks either clear differentiation between the body schema of the subject and the phenomenon that it is being matched to – paradigmatically the body of the other – or volitional (conscious) control or both. We believe that this is what underlies the neonatal mirroring of human infants (Meltzoff & Moore 1977) and chimpanzees (Myowa-Yamakoshi et al. 2004). The next step is *dyadic mimesis*, which features both differentiation between one's body and whatever it corresponds to and conscious control of the body's representational movements. We consider the capacity for *deferred imitation* to be clear evidence for such differentiation and volition, as well as the capacity for *mirror-self recognition*. (In the latter case, it is the mirror image that is the signifier, while one's own body is the signified.) What these very different skills share is a basic form of the sign function: understanding that one entity can *correspond to* another. Deferred imitation is claimed to be witnessed in human infants as early as 6 weeks (Meltzoff & Moore 1994), but this is rather controversial. At any rate, by 14 months children can perform bodily mimes of actions and events that they have observed previously (Piaget 1948), and around the same time they pass the mirror self-recognition test (Amsterdam 1972). Apes have some difficulties with both of these skills, but it appears that they are indeed capable of dyadic mimesis, reflected in both mirror-self recognition (Lin et al. 1992) and the ability to copy bodily shapes on command (Custance et al. 1995).

The crucial difference is in the next step in the hierarchy, *triadic mimesis*, when the sign function is recruited for communicative means so that an intentional bodily movement, a gesture, stands for an action, event, or object for an addressee. This *communicative sign function* is in essence what is involved in both indexical gestures (i.e., declarative pointing) and iconic gestures. Apes that have not been "enculturated" (cross-fostered) are poor at these skills, though some rudiments have been observed in captive gorillas (Tanner & Byrne 1996) and bonobos (Savage-Rumbaugh et al. 1977). Considering that acts of mimesis can be *interiorized* – that is, performed covertly in imagination – such covert mimetic schemas can be hypothesised to ground the meaning of the child's first words, and in particular the first verbs, the acquisition of which is claimed to be "the major turning point in children's transition to adult-like competence" (Tomasello 1992, p. 7). *Mimetic schemas* are representational and dynamic structures that are accessible to consciousness and *prereflectively shared*. Since they derive from imitating culturally salient actions and objects, both their representational and experiential content can be intersubjective – though not in the strong sense of being mutually known to be shared in the manner of symbols or conventions. What differentiates mimesis from language is above all that the latter is (in principle) fully conventionalized, that is, an object of common knowledge (Clark 1996) and systematic. Thus, signed languages such as American Sign Language constitute the fourth step of the mimesis hierarchy: *postmimesis*.

As sketched above, humans and apes begin to diverge as early as dyadic mimesis, but the difference becomes blatant with triadic mimesis, when mimetic acts and schemas are used for intentional communication. Considering this difference, it is unsurprising to find major differences in apes' and children's capacity for language acquisition. Bodily mimesis is also implicated in intersubjectivity. Gärdenfors (2003, ch. 4) proposes that the capacity for theory of mind be split up in several levels, which fits well with the general approach of Tomasello et al. In particular, we believe that the "shared intentionality" that is the focus of the target article cannot arise without the presence of triadic mimesis. The reason is that the participants can only identify (or create) the shared goal if they can communicate referentially about it, which can be achieved through triadic mimesis.

In conclusion, we hypothesize that the source of human cognitive specificity lies above all in two, mutually enforcing factors: (1) the capacity to form mimetic schemas: representations derived from imitation of public events, and thus basically intersubjective, and (2) the use of mimetic schemas for intentional communication: triadic mimesis. The first of these factors is predominantly representational and the second is communicative, and it is likely that the two have co-evolved. Like Tomasello et al., we consider the crucial human adaptation to be one of social cognition not specifically related to language, but to the motivation and ability

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to form *shared representations*. The difference is that our model, and in particular our construct of mimetic schemas, is more specific. We submit that our model accounts for much of the evidence involving the capacities and limitations of apes, summarized by Tomasello et al., and for the ease with which (nonautistic) children co-construct a world of meaning that is shared with their elders and peers. Thus, mimetic schemas serve as a prerequisite to the acquisition of language, which is just the icing on the cognitive cake, albeit a thick and rich icing.

Authors' Response

In Search of the Uniquely Human

Michael Tomasello, Malinda Carpenter, Josep Call, Tanya Behne, and Henrike Moll

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Abstract: As **Bruner** so eloquently points out, and **Gauvain** echoes, human beings are unique in their "locality." Individual groups of humans develop their own unique ways of symbolizing and doing things – and these can be very different from the ways of other groups, even those living quite nearby. Our attempt in the target article was to propose a theory of the social-cognitive and social-motivational bases of humans' ability and propensity to live in this local, that is, this cultural, way – which no other species does – focusing on such things as the ability to collaborate and to create shared material and symbolic artifacts.

R1. Introduction

The 31 commentaries on our target article were for the most part very helpful and thoughtful. We must therefore begin our response, as many authors of responses before us, by apologizing in advance to the commentators for not being able – due to space limitations – to respond with equal helpfulness and thoughtfulness.

R2. Understanding goal-directed action: Who does and who doesn't?

Behaviorists created a scientific paradigm on the fact that we do not observe the goals or psychological states of other organisms directly. Virtually everyone has gone beyond this now – with the current exceptions of **Dymond & McHugh**, who want to construe triadic interactions as "derived relational responding" and **Provine**, who wants to say that intentionality is overrated.

But what about chimpanzees and human babies? Do they understand others in terms of goals and other psychological states? **Povinelli & Barth** think that chimpanzees do not because experiments suggesting that they do (in which they, for example, react differently to purposeful and accidental actions) have other interpretations: the chimpanzees might just be reacting to behavioral cues associated with goal-directed action. This derived behaviorism (the organism has psychological states but doesn't know that others do) is based on a methodological argument that the internal psychological states of an actor can be inferred by an observer only if there is some external expression, and so why not just say the observer is reacting to the external expression and be done with it? One problem is that this argument also applies equally well to human beings, and so if one buys the methodological argument, then it must be assumed that all species, including humans, are equally "mindblind" – which these authors, in other writings, do not claim to be true. Moreover, empirically there are now several different paradigms suggesting that chimpanzees understand that others have goals and see things, and to explain them all without positing a knowledge of psychological states one needs a whole battery of unrelated behavioral cue-reading heuristics based on either innate mechanisms or learning histories that are, to us at least, quite implausible (there is certainly no independent evidence for them). **Watson** would also like to get rid of the understanding of psychological states as a basic cognitive skill, claiming that "intentions and other dispositional states may be inferred logically from an evolved commitment to determinism." In other words, organisms understand only causality, not intentionality, and so Mom's behavior is explained in the same way as a rock's – except that the timing of the contingencies is a bit different. But this cannot be right, as infants understand that people are not happy when their goals are unsatisfied, which must be based on some kind of teleological reasoning in which the actor compares the real state of affairs (as he perceives it) to some desired state of affairs represented internally – a process rocks simply do not engage in.

Perner & Doherty also believe that infants have some kind of externalist way of explaining the behavior of others that does not rely on an understanding of others as goal-directed agents with internal goals. Only when children can understand beliefs, which may be false, can they be said to truly understand the internal mental states of others. The basic argument here is that nothing short of beliefs are considered truly representational because, for example, "goals cannot be misrepresented." But, as first argued by Tomasello (1995), goals can be unsatisfied and the fact that infants understand this – and, again, understand that the actor is not happy when his goals are unsatisfied – is a major piece of evidence that infants understand something about others' internal goals. And goals do have representational content – the actor mentally represents the state of affairs desired – it is just that there is not, as there is in the case of beliefs, a commitment to the "truth" of this representation. But why should truth be the be all and end all? In other words, we simply do not buy the overly restrictive representationalist theory, which says that the only truly mental states are those accompanied by a commitment to their truth, and that knowledge of other representational states such as future-oriented goals is by definition externalistic and non-(meta)representational. **Fernyhough** seems to share some of this minimalist orientation, as he thinks we have overattributed to infants, and that true perspective taking can take place only through the mediation of public representations such as linguistic symbols. We of course agree that some special cognitive abilities emerge later in development with truth-bearing mental representations and linguistic representations (Tomasello & Rakoczy 2003), but we also think that earlier social-cognitive understandings not based on these things are more fundamental and get the process started.

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Poulin-Dubois agrees with our general approach, but also thinks that we give infants too much credit too early. Her main criticism, though, is not on the mark; that is, it is not the case that the explanation of our unwilling–unable experiments can be explained by the presence or absence of hand contact on the target object. On the opposite side of the issue, **Vaish & Woodward** think we do not give infants enough credit. They think that in our unwilling–unable experiments 6-month-old infants "probably lacked the communicative competence to express their frustration." But we were worried about that ourselves and compared the 6-month-olds and 9-month-olds on such things as banging the table, which both did quite often; we found that the older infants did this differentially, whereas the younger infants did not. We also think that their alternative interpretation of young infants' understanding in terms of an understanding of agent–object relations turns totally on how one characterizes infants' understanding of *agent* – that is, as animate, goal directed, or intentional, depending on the way the constitutive components of intentional action are understood.

We should note here that **Dominey**'s ideas about how to implement the construction of skills of goal-directed action – with variables in them – is very helpful in this context because it lays out explicitly the kinds of cognitive representations and learning mechanisms that are required for organisms to build up both their knowledge and adaptive behavioral skills.

R3. Collaboration and shared intentionality: Who does and who doesn't?

Schuster, Boesch, and **Kuczaj & Highfill** want to know why we don't include chimpanzees, lions, and hyenas among species that truly collaborate and share intentions. There are two answers: one theoretical and one methodological/empirical. The theoretical answer is that terms like *cooperation* are natural language terms that have many and broad meanings and, while these other species clearly cooperate with one another in a broad sense, it is not clear that they form with one another joint goals and intentions and attend to things jointly – which is our more narrow definition of collaboration and shared intentionality, and which underlies such uniquely human activities as symbolic communication. And so Schuster contrasts two forms of chimpanzee hunting: "helter-skelter running in all directions" and "organized, intentional group attacks," and Boesch claims that chimpanzees perform "complementary hunting roles." However, the question is whether these "organized intentional group attacks" and "roles" are really characterized by joint goals and plans among the participants – and that raises the methodological/empirical issue. Naturalistic observations are the starting point for the scientific investigation of animal behavior, but, to answer questions about underlying cognitive processes, controlled experiments are required.

All of the observations that **Shuster**, **Boesch**, and **Kuczaj & Highfill** report are more plausibly explained in other ways. For example, Boesch claims that we ignore field data demonstrating that, in their group, hunting chimpanzees do have shared goals and intentions. We know these data, but, again, they have many interpretations in terms of the cognitive processes involved. One of Boesch's key observations is that chimpanzees playing different 'roles' in the group hunt obtain different amounts of food – which raises the question of why anyone should play a less rewarded "role," such as "driver," unless it had some notion of a collaborative activity with a shared goal. The answer is that under certain conditions – for example, when the prey is low in the tree or other chimpanzees have already staked out the best locations – the individual determines that its best chance is to give chase (what a human may call the driver role) and it might get lucky. Boesch also says that "individuals may even shift roles during a given hunt, demonstrating a capacity for role reversal and perspective taking." Obviously, however, individuals may shift activities in the hunt for many different reasons without understanding a shift in perspective or role. A second observation is that at the end of the hunt the individuals who hunted (especially those who were 'blockers' and 'ambushers') get more meat from the capturer than those who did not. However, factors such as age, hunting experience, and dominance tend to be confounded with these different 'roles' (e.g., Boesch 2002; Boesch & Boesch-Achermann 2000), making it impossible to distinguish whether meat access is directly influenced by the hunter's 'role' or by his age or dominance status (see also Watts & Mitani, 2002, for similar observations of the chimpanzee community at Ngogo, Kibale National Park). And, in any case, using Boesch's soccer analogy, if everything were really collaborative wouldn't everyone on the team get an equal winner's share (not the most going to the goal scorer, i.e., capturer)? The overall point, once again, is that the same behavior may be generated by different underlying cognitive mechanisms and to detect these one needs experiments – whether these take place in the laboratory or in the field. Hopefully, in future research, someone will devise an experimental analog of chimpanzee group hunting that will enable us to test these kinds of competing cognitive hypotheses.

Horner, Bonnie & de Waal (**Horner et al.**) believe that an experiment from more than a half-century ago settled the issue for chimpanzees: Crawford (1937) found that two juvenile chimpanzees cooperated to pull in a heavy box with food on top. But the fact is that those two juvenile chimpanzees did *not* cooperate with each other spontaneously at all, as is clear both in the original paper and in textbook reports of it (e.g., see Tomasello & Call 1997). Because of this, Crawford trained each individual to pull when he said "Pull!" Then when he put them back together and said "Pull!", lo and behold: cooperation! These individuals then went on to do some interesting things – most especially, encouraging the other to do his job – but in subsequent experimental studies that have not trained individuals initially (none of which are cited by these authors) such encouragement has not been observed – leading to the question of what this behavior means.

Relatedly, **Horner et al.** are on the side of those who think that chimpanzees have humanlike culture. In support of this view, they report that examples of "unrewarded behavioral copying include the spread of hand-clasp grooming." But hand-clasp grooming has arisen separately in several different chimpanzee groups that have never had contact with one another, suggesting that it arises spontaneously quite easily, and there are no observations or experiments to establish how it might "spread," for example, whether by social learning through observation of others, by direct participation as recipient, or by rapid individual

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invention. These authors also use the example of ant dipping as a cultural behavior, since chimpanzee individuals in two different groups in Africa dip for ants differently. But this example has now been analyzed in detail by Humle and Matsusawa (2002 – not cited by these authors) who, to cut a long story short, found that the differences in chimpanzee behavior were directly attributable to the different behavior of the ants at the two locations. This study is also not cited by **Hatano & Takahashi**, and this is important because basically none of the field examples they cite as evidence of humanlike culture in chimpanzees has been analyzed in as much detail as the ant-dipping example.

Nor does either of these sets of authors explain the many negative findings from the experimental literature on imitation in nonhuman primates, including those in which apes could have copied subjects from their own group, in some occasions their own mothers (e.g., see Call & Tomasello 1994; Call et al. 2005; Tomasello et al. 1997). **Horner et al.** cite one of their recent studies as evidence of imitation and argue that chimpanzees imitated only when they could not see the causal relations in the apparatus. Although the use of different strategies depending on the causal structure of the task is an interesting result, this study, like its predecessors (e.g., see Whiten et al. 1996), is still vulnerable to alternative explanations in terms of emulation learning (subjects copying environmental results, not actor behavior). Moreover, there are other studies in which the causal relations were equally opaque and apes did not imitate (e.g., see Call & Tomasello 1995). So chimpanzees (and other apes) may have something that could be called culture in the broad sense, but it almost certainly is something significantly different from the human version.

Kuhlmeier & Birch pick up on our theme of chimpanzees as primarily competitors and wonder whether they might collaborate more deeply if they were doing so in order to compete with another individual. We wondered the same thing, and in ongoing work in our laboratory (Melis et al., in press) we tested this in a kind of tug-of-war paradigm featuring two individuals against one bigger one. We found that it made no difference to the quality of collaboration. But we agree wholeheartedly with these authors that negative conclusions should not be reached until all experimental avenues have been exhausted – and that is why we continue to search for evidence of chimpanzee collaboration, narrowly defined as joint goals and intentions, in our laboratory. We should also point out that we have recently found similar negative results in collaborative tasks when the subjects are young chimpanzees raised mostly by humans (Tomasello & Carpenter 2005; Warneken et al., submitted), which argues against **Gardner**'s contention that our negative results may be due to the impoverished rearing conditions of the captive chimpanzees in most studies.

We are frankly surprised that we did not receive more criticism of our claim that human infants share goals and intentions at 14 months of age, since this claim has the least empirical support of any in the article – which is why we are currently working on it in our laboratory. **Brownell, Nichols & Svetlova** (**Brownell et al.**) make the excellent point that even if our claims are true for infants collaborating with adults, they are almost certainly not true for infants collaborating with peers – since 1-year-old peers collaborate with one another very little. This is an important point because if we are looking for skills underlying the emergence of collaboration in evolution, peer collaboration is the more accurate analogy – although it would be peer collaboration among adults, not infants. Nevertheless, one could argue that for purposes of identifying infant social-cognitive skills it is most important to find the age at which infants can collaborate with anyone, provided that in the experiment the collaborator's behavior is carefully controlled (e.g., as in Warneken et al., submitted), so that we can set a kind of lower bound on infants' ability to engage in truly collaborative activity. We agree with **Feldman, Swain & Mayes** (**Feldman et al.**) that interactive synchrony is an important component in collaborative interactions, but we also believe that additional components (e.g., the motivation to share activities and experience with others) are needed before we get to the kind of shared intentionality underlying human cultural cognition.

We are heartened that experts in autism in general find our framework helpful and not totally inaccurate. **Charman** is right to point out that the claim that intention reading in autism is intact is based on fairly thin, and not totally consistent, evidence. And although there are almost no studies of the collaborative skills of children with autism (we are working on it), there are many studies of joint attention, and they consistently find deficits in the autistic population. **Mundy** relates this very nicely to a kind of social-motivational-affective substrate of a kind consistent with **Hobson**'s general approach, including some possible neurodevelopmental substrates. We must be careful about this kind of proposal, however, because, as **Verbeke, Peeters, Kerkhof, Bijttebier, Steyaert & Wagemans** (**Verbeke et al.**) point out, in many ways high-functioning children with autism have "intact social interest and initiate social contact as frequently as other children" (and by all accounts have basically fully natural attachments to their caregivers). But we would claim that social interest, attachment, and initiating social contacts are not the same thing as a motivation to share goals, interests, and intentions.

And so while some commentators think our porridge is too hot (we overattribute to human infants and/or apes) and others think it is too cold (we are too hard on the little tykes and/or our hairy cousins), we think it is just right. All apes including humans understand intentional action (perhaps with some quantitative species differences), but only human apes engage with one anther in the kinds of shared intentionality involved in the creation and use of such things as linguistic symbols and cultural institutions.

R4. Alternative magic bullets

Turning now to issues of process, we argued in the target article that explaining human cognitive and social uniqueness requires complex stories in three time frames: phylogeny, history, and ontogeny. We zeroed in mainly on shared intentionality and its emergence in ontogeny and phylogeny. Some of the commentators provided alternative "magic bullets" for explaining the key features of human cognitive and social uniqueness, stressing other aspects of the process that we did not highlight. But, in nearly all of these cases, we find that these alternative accounts basically sneak in through the back door one or another form of shared intentionality as a kind of hidden premise. (Or else they manage to ignore it, as when **Dominey** describes a precursor scenario in which the adult and child simultaneously have goals toward each other – they each want the

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other to help them play the game [as a social tool] – but they have no joint goals or intentions together.)

Most obvious for us is the case of language. **Bickerton**, and to some degree **Fernyhough**, think that much of human cognitive uniqueness is due to language. Who could disagree with that? The question is, what is language? Where did it come from and what is its nature? Bickerton would like to provide a coevolutionary account in which "every increment in linguistic skill could lead to an increase in shared intentionality, and vice versa." Again, who could argue? The crux of the matter comes in his further statement about the beginning of the process. He says, "Very little understanding or sharing of intentions – perhaps little if any beyond what contemporary apes possess – would have been required to comprehend and act on the kind of single-unit utterances with which language must have begun." If this is true, then why don't apes use symbolic utterances with one another today? Not only do they not use symbolic utterances with one another, they do not even point for one another or show things to one another. And, even more amazingly, they do not even seem to understand pointing (see Tomasello, in press). And so we would argue that modern apes do not really understand communicative intentions of the cooperative (Gricean) kind, clearly a prerequisite for understanding symbols (and this even applies to language-trained apes in the sense that they still communicate seldom if ever simply to share information with others cooperatively and/or declaratively [Tomasello & Call 1997]). Humans of course do express and understand cooperative communicative intentions, and, as Clark (1996), Sperber and Wilson (1986), and Tomasello (in press) have all argued, this requires both shared attention and action: we both agree on the meaning of the symbolic convention and negotiate its communicative significance in particular joint-action contexts. So we agree with Bickerton that a coevolutionary process is at work here – we would just stress that to get the process started one needs some forms of shared intentionality. The idea of language without shared intentionality, even in one-unit expressions, is simply incoherent.

Gergely & Csibra come from a different angle, but they also attempt to sneak in shared intentionality through the back door (and also **Markson & Diesendruck**, who make a similar argument). Their evolutionary account is that, as humans began making tools involving complex manufacturing (which could take place at a different location than use), "increasingly sophisticated teleofunctional understanding of tools" was selected. As the functions of tools became increasingly "opaque" to observers, pedagogy became important to help youngsters learn to use these opaque tools. But pedagogy essentially reduces to the expression of communicative intentions à la Sperber and Wilson (1986); that is, the teacher makes mutually manifest her intention that the learner see/know/learn something which she assumes to be relevant for the learner – and the learner knows that the teacher is doing this and makes the relevant inferences. Such pedagogy clearly rests on shared intentions and attention, as we argued at length in the target article, since shared goals (or some other kind of shared common ground) is necessary to determine relevance. Where Gergely & Csibra go wrong is that they assume that what we mean by "the motivation to share psychological states" is a kind of altruism for sharing information freely and engaging in declarative communication with no immediate benefit to the speaker. But the whole point of the Sperber and Wilson analysis is that there are different levels of motivation involved, and that whatever the ultimate goal of the speaker – even if it is for selfish/deceptive reasons in telling someone to do something – the speaker and hearer must cooperate for the message to be received. And so Gergely & Csibra think that by focusing on tool use and the teaching of tool use, as instrumental food-getting acts, they have no need for shared intentionality, whereas we would argue that pedagogy and cooperative communication already assumed shared intentionality.

Zlatev, Persson & Gärdenfors (**Zlatev et al.**) attempt to sneak in shared intentionality in a different way. The initial steps of bodily mimesis that they posit are fine. But they argue that the crucial difference between humans and, for example, other apes comes in triadic mimesis "[w]hen the sign function is recruited for communicative means so that an intentional bodily movement, a gesture, stands for an action, event, or object for an addressee." Just as **Bickerton** and **Gergely & Csibra**, they do not recognize that such things as pointing and iconic gestures assume a shared attentional framework, a communicative common ground, that makes such gestures meaningful. To illustrate: If I meet you on the street and point to a building, your natural response will be "Huh!?" You can follow my point to the building, but you do not know why I want you to do so. In the terminology of Sperber and Wilson (1986), you do not know why I think that building is relevant for you. But if you and I both know, and know that we know, that you are searching for your dentist's office, then the point becomes immediately relevant and meaningful in this shared context. And so the key move to triadic mimesis again assumes what it attempts to explain: shared intentionality.

Because this is such an important point, let us elaborate by detailing an experimental paradigm (used with both chimpanzees and children) that we described only very briefly in the target article. In this paradigm, someone hides food in one of several opaque buckets. Then, as a kind of control test, another person walks over and tips the bucket with food so that the chimpanzee can see it. When the buckets are then pushed over to the chimpanzee, she of course knows immediately where the food is and takes it. However, when we do exactly the same thing except that the second person doesn't tip the bucket so the chimpanzee can see the food, but only points to the bucket containing the food (or uses some other kind of indicating gesture – always with gaze alternation between location and subject), the chimpanzee is lost; when it is her turn to choose, she chooses randomly (see Call & Tomasello [2005] for a review). In contrast, human infants find this task relatively simple from soon after their first birthday, while they are just beginning to learn language (Behne et al. 2005). So what is the difference? The key one is that the infant knows that she and the adult are playing a hiding–finding game: the child's role is to find the toy, and the adult's role is to help her. So when the adult points to one of the buckets, the child immediately sees this as relevant to this game and the adult's role in it; that is, when the pointing act is seen as helping in this game (it is "for me"), then locating the hidden toy is trivial. The chimpanzee, in contrast, does not understand the collaborative structure of the game. She thus follows the point to the bucket, but then says to herself, in effect, "There's a bucket. That's boring. Where's the food?" She does not share the collaborative context with the hu-

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man that would make the pointing relevant to her searching activities. And so, in general, we find that all of the attempts to replace shared intentionality as fundamental, using language or other forms of communication, neglect the hidden infrastructure of human cooperative communication in which conventional behaviors gain their significance only in relation to some kind of shared attentional or action context.

Rochat and **Lewis** attempt to get beneath shared intentionality and explore the contribution of a sense of self. This is an aspect of the process that we ignored in our target article, but that we actually think is very important. We argue in several places that in true collaboration both participants understand the collaborative interaction from a "bird's-eye view" in which both roles are represented from an outside perspective (and so are interchangeable). Obviously, to be able to do this, the infant has to have some ability to conceptualize the self. In Tomasello (1994, 1995, 1999), the proposal was made that this could only be done when the infant could take the perspective of the other on the self. Following Barresi and Moore (1996), beginning to take an outside perspective on the self most likely originates in social interactions (not yet shared) in which both participants are focused on a common object or activity; then the infant begins to make comparisons between the common entity as viewed from her own first-person perspective and her third-person perspective on the partner. So perhaps we might agree with Rochat and Lewis on something like the following. Very young infants participate in interactions that are shared emotionally, but they are not yet collaborative in our more narrow sense – at least partly because infants cannot conceive of themselves in the same representational format in which they conceive of the other. Once that is accomplished – by the infant simulating the other's view of herself – then the stage is set for truly collaborative interactions with shared goals and interchangeable roles.

Hobson takes issue with our attempt to move beyond simple identification as the hypothesized basis for shared intentionality. As we make clear in the original article, we still believe that the infant's identification with others is a crucial and necessary part of the process. The crux of the issue is that Hobson claims that "identification 'proper' includes a partial assimilation of the attitudes and mental orientation of someone else, such that one preserves something of the 'otherness' of the attitudes perceived and assimilated." This definition involves much more in the direction of collaboration and sharing than we ourselves put into the simple process of identification – which we think of more as simply the infant aligning herself with the emotions and psychological states of the other, without necessarily conceptualizing and comparing herself with the other in the process. We also think this same issue underlies Hobson's critique of our use of simulation theory. For infants to simulate the psychological states of another (e.g., to imagine what the other is feeling when he is frustrated in his actions toward a goal), they do not need to conceptualize the self or the other at all, where conceptualize means something like "take an outside perspective on," as Gordon (1986) and others have pointed out repeatedly.

We thus think that more work on the understanding of self and the process of identification will lead to a deeper understanding of how human beings in evolutionary time, and current human infants in ontogenetic time, can make the transition from understanding to sharing intentions. But positing magic bullets that presuppose shared intentionality does not, in our opinion, provide alternatives to our account.

R5. Cognition and motivation: Phylogeny

Lyons, Phillips & Santos (**Lyons et al.**) think that motivation, at least as we use it, is a fuzzy and/or not well-operationalized term (see also **Kuhlmeier & Birch**, **Gauvain**, and **Markson & Diesendruck**) and cannot carry the weight we wish to place upon it. We think that the major problem here is more terminological than substantive – and we ourselves struggle with how best to talk about these things. Our best shot is this. When Nature selects for a behavioral or cognitive skill, there must also be motivation to apply it. Conversely, motivation is motivation to or for X, which already implies some understanding or representation of X. Thus, we see all cognitive skills as having representational and motivational aspects. Specifically, these authors quote our claim that "there is a special kind of shared motivation in truly collaborative activities. . . . each interactant has goals with respect to the other's goals." This means that each interactant represents the goals of the other, perhaps even as these are related to its own goals – clearly a representational achievement. Their preferred alternative is to posit a dedicated module in chimpanzees that reads intentions only in competitive contexts, but even modules need a motivational dimension or else they would simply languish in the organism's head, spinning their mechanistic wheels and contributing nothing to its adaptive fitness. And we think it is just empirically not the case, as Lyons et al. claim, that apes' social-cognitive skills are confined within a competition module – whatever that could possibly mean. We agree that competition may present a special context for application of the skills – as we argued beginning with the reports by Hare et al. (2000, 2001) – both because competition is a simpler social situation to understand and navigate cognitively than is cooperation, which requires negotiation, and because competition is especially motivating for apes. But apes also use their social-cognitive skills on occasions when they are simply exploiting others, for example, by following their gaze or predicting their goal-directed actions when they are not even interacting (see Tomasello & Call, in press).

Ross has some of the same worries about cognition versus motivation, but he poses the question especially sharply by asking us to attempt to discriminate between "the hypotheses that (1) humans retain the generic ape cognitive architecture with modified utility functions, and (2) motivational adaptations in hominids led to cognitive adaptations in them." In actuality, though, we do not think that either of these stark alternatives can really work. The first cannot work because it is extremely unlikely that apes in general would have the cognitive architecture for shared intentionality and no motivation to use it. It is a possibility, of course, because such cognitive architecture could have evolved as an evolutionary "spandrel" in apes, and it just hung around with no function until humans found one for it. But this account would need to specify what supports the spandrel, as we are talking about very expensive brain tissue here. As for the second, motivational adaptations can lead to cognitive adaptations, but there are some chicken-and-egg questions in this that require coevolutionary pro-

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cesses. So, for instance, let us assume some apelike australopithecines, and some of them are especially motivated to hunt together with others, and that some change in the ecological niche favors these individuals; the motivation to hunt together is selected. The individuals of succeeding generations then are in a new selective environment in which behavioral and cognitive skills for more skillful collaborative hunting are selected in a way they were not before the new motivation became the norm. So, in this scenario, the complex behavior of collaborative hunting got its start motivationally, but then took off cognitively. Thus, what has to evolve is a cognitive skill or propensity, or set of cognitive skills and propensities, with both representational and motivational aspects.

But, as we say, in either case there must be coevolutionary processes in which there is a dialectic between motivational and representational components. Returning to the real world, we think there are actually two possible scenarios of the origin of shared intentionality in humans, which are at least somewhat empirically distinguishable based on research with apes and humans. First, following some previous writings by Gergely and Csibra (e.g., in press), let us consider the possibility that chimpanzees understand goal-directed action and perception in an externalist way; that is, they perceive goal-directed action directly, in an obligatory, Michottian kind of way. This would mean that even though they are sensitive to the goals and perceptual orientations of others, as demonstrated in experiments, they do not understand the psychological states of others as in some sense analogous to their own. And so their dealings with the goals and perceptions of others are done on a different basis than that of humans. We might say that the human kind of understanding of goals and perceptions is representationalist (though not necessarily truth bearing à la **Perner**), whereas the ape kind is not. Then, consistent with **Hobson**'s hypotheses, humans come to identify with others in a way that enables them to make this equivalence, and so humans now understand the goals and perceptions of others in a new way, that is, on analogy to their own (a different version of **Povinelli & Barth**'s redescription hypothesis). This would then set the stage for various skills and motivations of shared intentionality in humans and only humans.

In contrast, let us consider the possibility that apes understand the goals and perceptions of others in the same way as humans, that is, on analogy with their own. This is a reasonable possibility because they engage in neonatal imitation (and adult apes can be trained to mimic bodily motions as well), suggesting that at the very least they identify their own bodily motions with those of others. Under this assumption, human evolution began at a different starting point, and what we need is either some deeper form of identification, or motivation, or possibly some new cognitive architecture for shared intentionality. This new cognitive architecture might involve something like the ability to comprehend and express communicative intentions (the "ability to communicate relevant information" of **Gergely & Csibra**), some of the other kinds of representations talked about by **Ross** and **Lyons et al.**, or simply dialogic representations of the kind we talked about in the target article (arising, as it were, sui generis). Again, this might set the stage for the later development of either new cognitive architecture or new motivations in the same general direction.

As we say, these two different possibilities generate some testable hypotheses – most especially those involving the understanding of intentional action by apes and humans, and whether it is done on the same basis. Our own best guess at this point is that something midway between these two might be right. Humans started with an ape understanding of intentional action based on bodily identification. But then about 2 million years ago, when the manufacturing of tools began to be especially important for humans, those individuals who could analyze intentional actions even more deeply, relating perception to action in ways enabling them to determine whether the action was rational and so worthy of imitation (**Gergely & Csibra**), were at a selective advantage. This led to deeper forms of identification, where *deeper* means identifying not only with the goal-directed bodily actions and perceptions of others, but also with the rational choices they are making in both action and perception (attention). Crucial here, then, would be knowing whether apes can engage in some kind of rational imitation or in some other way demonstrate that they understand that others make rational choices. We are working on it, but so far there is no evidence that they do (Tomasello & Carpenter 2005).

But then we still believe something additional is needed, and that that happened with modern humans and would have involved new kinds of social motivations, social emotions, and social-cognitive skills. These then enabled the development of a full-fledged shared intentionality involving joint goals, joint intentions, and joint attention, which is sometimes used for something in the direction of altruistic ends – for example, simply sharing information and experience with others for no reason other than it feels good to do so (declarative communication). We think that these kinds of things probably developed in some kind of group-level selection (e.g., cultural group selection à la Boyd and Richerson [2005]), but that is a different part of the story.

R6. Cognition and motivation: Ontogeny

As psychologists, we would prefer not to end with hypothesized evolutionary scenarios, but rather with our ontogenetic model, of which more components are directly testable. We proposed two lines of development: (1) a general ape line of understanding intentional action (perhaps souped up to include rational decision making), and (2) a uniquely human line involving the motivations and skills to engage in various kinds of shared intentionality. The sharing line begins with emotions in early infancy, and the understanding intentional action line begins in earnest at around 9 months of age with the understanding of action as goal directed, with skills of shared intentionality emerging soon after as a result of the interaction of these two lines. The uniqueness of this ontogenetic scenario, as compared with that of other apes, is perhaps best exemplified in those activities of human infants that seem to be motivated by one and only one thing: the desire to share experience with others. Thus, even before language begins, human infants get real psychological pleasure from just pointing to interesting things, or holding up interesting things, for other people – who then share enthusiasm with them. We think that this special motivation – as all special motivations in evolution – is a sign that Mother Nature has built a special system that she wants to make sure is used.

There are many things that could falsify these overall hypotheses, most importantly:

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- Demonstrating that apes have the same motivation to share as humans.
- Demonstrating that apes do not understand intentional action at all, in which case that might be the uniquely human part.
- Finding that children's participation in shared intentionality is not related to either their understanding of intentional action and/or their motivation to share psychological states with others.

Other findings could falsify the particular ontogenetic trajectory we hypothesize; for example, finding that young human infants are not really sharing emotions the way we think they are; finding that we have overinterpreted 9-month-old infants' (or underestimated 6-month-old infants') behavior in experiments investigating their understanding of intentional action; or finding that human infants do not really engage in collaborative and communicative interactions until much later in ontogeny. In general, the whole account would be much helped as well by determining whether apes understand the rational dimensions of action (in terms of the choice of intentional actions) and perception (in terms of the choice of attentional focus), and how closely their early dyadic interactions resemble those of human infants and adults.

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Letters "a" and "r" appearing before authors' initials refer to target article and response, respectively.

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