Cooperation and human cognition: the Vygotskian intelligence hypothesis

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Nicholas Humphrey's social intelligence hypothesis proposed that the major engine of primate cognitive evolution was social competition. Lev Vygotsky also emphasized the social dimension of intelligence, but he focused on human primates and cultural things such as collaboration, communication and teaching. A reasonable proposal is that primate cognition in general was driven mainly by social competition, but beyond that the unique aspects of human cognition were driven by, or even constituted by, social cooperation. In the present paper, we provide evidence for this Vygotskian intelligence hypothesis by comparing the social-cognitive skills of great apes with those of young human children in several domains of activity involving cooperation and communication with others. We argue, finally, that regular participation in cooperative, cultural interactions during ontogeny leads children to construct uniquely powerful forms of perspectival cognitive representation.

Keywords: communication; cooperation; human children; primate cognitive evolution; social intelligence; Vygotskian intelligence hypothesis

1. INTRODUCTION

Nicholas Humphrey's (1976) social intelligence hypothesis proposed that the major engine of primate cognitive evolution was social competition. This competitive aspect was emphasized even further in similar later proposals espousing 'primate politics' (de Waal 1982) and Machiavellian intelligence (Byrne & Whiten 1988). In all of these proposals, the basic idea was a kind of arms race in which individuals who outsmarted others—who were also trying to outsmart them—were at a competitive advantage evolutionarily.

Interestingly, at about the same time as Humphrey's original proposal, Lev Vygotsky's (1978) general theory of culture first appeared in English translation. Vygotsky also emphasized the social dimension of intelligence, but he focused on cooperative things such as culture, collaboration, communication and teaching, and he was concerned more with ontogeny than with phylogeny. Vygotsky argued and presented evidence that the cognitive skills of human children are shaped by, or in some cases even created by, their interactions with others in the culture or with the artefacts and symbols that others have created for communal use. In all, it is difficult to find reference in any of Vygotsky's work to competition; the stress is almost exclusively on the crucial role of cooperative social interactions in the development of cognitive skills.

The resolution to this seeming conflict—an emphasis on competition versus cooperation in the formation of primate cognitive skills—is straightforward. Humphrey and his successors were talking mostly about non-human primates, whereas Vygotsky was talking mostly

about humans. Among primates, humans are by far the most cooperative species, in just about any way this appellation is used, as humans live in social groups (a.k.a. cultures) constituted by all kinds of cooperative institutions and social practices with shared goals and differentiated roles (Richerson & Boyd 2005). A reasonable proposal is therefore that primate cognition in general was driven mainly by social competition, but beyond that the unique aspects of human cognition— the cognitive skills needed to create complex technologies, cultural institutions and systems of symbols, for example—were driven by, or even constituted by, social cooperation (Tomasello *et al.* 2005).

We call this the Vygotskian intelligence hypothesis. Our goal in this paper is to provide evidence for this hypothesis by comparing the social-cognitive skills of great apes, mainly chimpanzees, with those of young human children, mainly 1-year-olds, in several domains of activity involving cooperation with others. These comparisons illustrate especially human children's powerful skills and motivations for cooperative action and communication and other forms of shared intentionality. We argue, finally, that regular participation in cooperative, cultural interactions during ontogeny leads children to construct uniquely powerful forms of cognitive representation.

2. GREAT APE SOCIAL COGNITION

A species' skills of social cognition are adapted for the specific kinds of social interactions in which its members typically participate. Thus, some non-social species may have very few social-cognitive skills, and even some social species may have no need to understand others as anything other than animate agents, since all they do socially is keep in spatial proximity to conspecifics and interact in very simple ways. However, for species that

are more intensely social—that is, those whose social interactions with group mates are complex and characterized by various strategies of competition and cooperation—it would seem to be a great advantage to understand others more deeply in terms of their goals, perceptions and behavioural decision making, so that their behaviour might be predicted in novel circumstances. Non-human primates clearly do this, but recent experimental research suggests that they do it much more readily in competitive, as opposed to cooperative, circumstances.

Take, for example, the question of whether chimpanzees understand what others see. Although chimpanzees follow the gaze direction of others quite readily, even to locations behind barriers (Tomasello *et al*. 1999; Bräuer *et al*. 2005), this could be accomplished by a very simple co-orientation mechanism not requiring an understanding of seeing. This non-cognitive explanation was, at one time, supported by two lines of research. First, in a series of experiments, Povinelli & Eddy (1996) tested young chimpanzees' understanding of how humans must be bodily oriented for successful communication to take place (see also Povinelli *et al*. 1999; Reaux *et al*. 1999). They trained subjects to approach and choose which one of two humans to beg food from—where one human was in a position to see their gesture and the other was not. In this Gesture Choice experimental paradigm, subjects did not gesture differentially for a human who wore a blindfold over his eyes (as opposed to one who wore a blindfold over his mouth), or for one who wore a bucket over his head (as opposed to one who held a bucket on his shoulder), or for one whose back was turned and was looking away (as opposed to one whose back was turned but who looked over his shoulder to the subject). Povinelli and colleagues thus concluded that chimpanzees do not understand seeing.

The second experimental paradigm causing chimpanzees problems is the Object Choice paradigm. In a number of different experiments from a number of different laboratories, chimpanzees have shown a very inconsistent ability to use the gaze direction of others to help them locate the food hidden under one of several objects. For example, Call *et al*. (1998) presented chimpanzees with two opaque containers, only one of which contained food (and chimpanzees knew that they could choose only one). A human experimenter then looked continuously at the container with food inside. Not one of six chimpanzees used this cue to find the food. Tomasello *et al*. (1997a) and Call *et al*. (2000) provided chimpanzees with several other types of visual–gestural cues (including pointing) in this same paradigm and also found mostly negative results (see also Itakura *et al*. 1999; Povinelli *et al*. 1999).

But concluding from chimpanzees' failures in these two experimental paradigms that they do not understand seeing would be premature. In a more recent series of studies, Hare *et al*. (2000) have shown that in the right situation chimpanzees can use the gaze direction of others to make an effective foraging choice. They do this, however, not when that conspecific is attempting to be cooperative, as in the Gesture Choice and Object Choice paradigms, but rather when the conspecific is attempting to compete with them for food. The basic set-up was as follows. A subordinate and a dominant individual were placed in competition over food. The trick was that sometimes the subordinate could see a piece of food that the dominant could not see due to a physical barrier of some sort. The general finding was that subordinates took advantage of this situation in very flexible ways—by avoiding the food the dominant could see and instead pursuing the food she could not see (and even showing a knowledge that transparent barriers do not block visual access). In a second set of studies, Hare *et al*. (2001) found that subordinates even knew whether the dominant had just witnessed the hiding process a moment before (they knew whether she 'knew' its current location even though she could not see it now).

The findings of these studies thus suggest that chimpanzees know what conspecifics can and cannot see, and, further, that they use this knowledge to maximize their acquisition of food in competitive situations. (See also Melis *et al*. 2006b; Hare *et al*. in press, for evidence of chimpanzees' ability to conceal their approach to food from the visual attention of a competitor.) The question is then why they cannot do something similar in the Object Choice and Gesture Choice paradigms. The key, in our opinion, is cooperative communication versus competition. The situation in which another individual is trying to inform them about the location of food, as in the Object Choice paradigm, is clearly not the one chimpanzees normally experience, since they spend their whole lives competing with group mates for food. And so the subject in the Object Choice paradigm does not take the gaze or point of the other as an informative cue because no individual would behave like that in the presence of food she could take for herself. Subjects in this experimental paradigm just do not know or care why the other is indicating one container and not another because such behaviour does not suggest the presence of obtainable food for them. In the Gesture Choice paradigm, subjects are choosing whom to communicate with, also a very unnatural situation. When experiments with the same logic are done—but without this element of choosing a communicative partner—chimpanzees perform much more impressively (Kaminski *et al*. 2004).

Human beings either have done well, or would very likely do well, in all of the experimental paradigms described above, both competitive and cooperative. It is not that human beings are not competitive—they most assuredly are—and they use their social-cognitive skills in competitive situations every day. But human beings can also coordinate well with others, and understand their intentional states, when cooperating or communicating with them. The difference between humans and chimpanzees in this regard is perhaps best illustrated by directly comparing young human children to our nearest primate relatives in tasks requiring skills of cooperative interaction and communication.

3. COOPERATIVE ACTIVITIES
Individuals of virtually all primate species engage in group activities on a daily basis. These activities may be considered cooperative in a very broad sense of the

term. However, we focus here on forms of cooperation much more narrowly defined. As in previous theoretical work (Tomasello *et al.* 2005), we use here a modified version of Bratman's (1992) definition of 'shared cooperative activities'. Joint or shared cooperative activities are mainly characterized by three features. First, the participants in the cooperative activity share a joint goal, to which they are jointly committed. Second, and relatedly, the participants take reciprocal or complementary roles in order to achieve this joint goal. And third, the participants are generally motivated and willing to help one another accomplish their role if needed (the criterion of 'mutual support' in Bratman's account).

One well-known phenomenon that has been suggested as a demonstration of cooperation in non-human primates is group hunting. Boesch and colleagues (Boesch & Boesch 1989; Boesch & Boesch-Achermann 2000; Boesch 2005) have observed chimpanzees in the Taï forest hunting in groups for arboreal prey, mainly monkeys. In the account of these researchers, the animals take complementary roles in their hunting. One individual, called the *driver*, chases the prey in a certain direction, while others, the so-called *blockers*, climb the trees and prevent the prey from changing directions. An *ambusher* then silently moves in front of the prey, making an escape impossible. Of course, when the hunting event is described with this vocabulary of complementary roles, then it appears to be a joint cooperative activity: complementary roles already imply that there is a joint goal, shared by the role-takers. But the question really is whether this vocabulary is appropriate at all. A more plausible characterization of the hunting event, from our perspective, is as follows: each animal fills whatever spatial position is still available at any given time so that the encircling is accomplished in a stepwise fashion, without any kind of prior plan or agreement to a shared goal or assignment of roles. Then, without pursuing a joint goal or accomplishing a certain role within a higher order framework, each individual chases the prey from its own position (see also Tomasello *et al.* 2005). This event clearly is a group activity or group action, because, to use another one of Bratman's terms, the chimpanzees are 'mutually responsive' as they coordinate their behaviours with that of the others in space and time (see also Melis *et al.* 2006*a*). But what seems to be missing is the 'together-ness' or 'jointness' that distinguishes shared cooperative activities from other sorts of group actions. This interpretation is strongly supported by studies that have investigated chimpanzees' abilities to cooperate in experimental settings.

In one study, Warneken *et al.* (2006) tested three juvenile human-raised chimpanzees with a set of four different cooperation tasks. In two of these tasks, a human tried to engage the chimpanzee to cooperate in order to solve a problem (e.g. extracting a piece of food from an apparatus). In the other two tasks, the human tried to engage the ape to play a social game. The authors looked at two things: the chimpanzees' level of behavioural coordination and the chimpanzees' behaviours in the so-called interruption periods in which the human suddenly stopped participating in the activity. The results were very consistent: in the

problem-solving tasks, chimpanzees coordinated their behaviours quite well with that of the human, as shown by the fact that they were mostly successful in bringing about the desired result, as, for instance, extracting the piece of food from the apparatus. However, they showed no interest in the social games, and so the level of coordination in these tasks was low or absent. Most important was what happened when the human suddenly interrupted the activity. In none of the tasks did a chimpanzee ever make a communicative attempt to re-engage the partner. Such attempts were missing even in the cases where they should have been highly motivated to obtain the desired result, as in the problem-solving task involving food. The absence of any efforts by the chimpanzees to re-engage their human partner is crucial: it shows that the chimpanzees did not cooperate in the true sense, since they had not formed a joint goal with the human. If they had been committed to a joint goal, then we would expect them, at least in some instances, to persist in trying to bring it about and in trying to keep the cooperation going.

For humans, the situation is different from very early on in ontogeny. Warneken *et al.* (2006) conducted an analogous study with 18- and 24-month-old human children. Unlike the chimpanzees, children cooperated quite successfully and enthusiastically not only in the problem-solving tasks, but also in the social games. For example, these infants enjoyed playing a 'trampoline' game together, in which both partners had to simultaneously lift up their sides of a small trampoline with their hands, such that a ball could bounce on it without falling off. Most importantly, when the adult stopped participating at a certain point during the activity, every child at least once produced a communicative attempt in order to re-engage him. In some cases, the children grabbed the adult by his arm and drew him to the apparatus. The older children of 24 months of age also often made linguistic attempts to tell the recalcitrant partner to continue. Unlike the chimpanzees, we thus find in human infants the ability to cooperate with joint commitment to a shared goal: the children 'reminded' the recalcitrant partner of their shared goal and expected him to continue in order to achieve it. There was even some evidence that the children already understood the normativity behind the social games and the way they 'ought to be played'. For example, in one of the games, they always used a can in order to catch a toy when it came falling out of one end of a tube after their partner had thrown it in from the other end. They could have also caught it with their hands, but they preferred to do it the way it had previously been demonstrated to them. This implies that they perceived the can as a constitutive element of the game, and they wanted to play the game the way it 'ought' to be played. The chimpanzees, on the other hand, never used the can in order to catch the toy—if they engaged in the game at all, they simply used their hands.

It thus seems that human infants by the age of 18 months, in contrast to apes, are able to jointly commit to a shared goal. The second criterion for cooperation, as we define it, is role-taking. True cooperation should involve that the partners perform reciprocal roles and also understand them, in the sense that they coordinate their actions and intentions with the possibility of

reversing roles and even helping the other with his role if needed. This form of role-taking would suggest that each partner represents the entire collaboration, its shared goal and reciprocal roles, holistically from a 'bird's eye view' instead of just from within whatever role they happen to be taking at the moment. One study purporting to show role reversal in chimpanzees is that of Povinelli *et al.* (1992). In that study, chimpanzees were trained in one of two roles of a cooperative hiding game with a human. Some chimpanzees were trained in the role of a communicator, who indicated to the human where a piece of food was located. The other chimpanzees were trained in the complementary role of the 'operator', who extracted the food from the location indicated by the human. When the chimpanzees had learned their initial role to criterion, a role switch was initiated and the question was whether the chimpanzees would spontaneously reverse roles. One of the chimpanzees, whose initial role was that of the communicator, was immediately successful as operator after the switch. But the problem is that this individual most likely comprehended human indicating gestures *before* the study—as this animal had had extensive interactions with humans. The two individuals that switched to be a communicator also seemed to reverse roles effectively, as they were reported to provide the human with cues about the location of the food fairly quickly. However, the problem in this case is that it is not clear that the chimpanzees actually produced any communicative signals at all, but instead the humans simply interpreted their natural bodily orientation to the food.

A more well-controlled investigation of role reversal skills in chimpanzees was done by Tomasello & Carpenter (2005) with the same three young human-raised chimpanzees which participated in Warneken *et al.*'s (2006) study. In this study, a human demonstrated to the chimpanzee various actions with each of four pairs of objects. For each pair of objects, one functioned as a 'base' and the other as an 'actor'. The human then demonstrated to the chimpanzee how the two, the actor and the base, are put together. For instance, she put a 'Tigger' figure on a plate and 'Winnie the Pooh' figure in a little toy car. Then E gave the actor (e.g. Tigger) to the chimpanzee and held out the base (the plate) towards the chimpanzee, thus offering that the chimpanzee put the actor on the base to complete the act. If chimpanzees did not perform the role of putting the actor on the base spontaneously, E encouraged them to do so by vocalizing and, and if they still did not respond, by helping them put the actor on the base. To test for role reversal, E then handed the chimpanzee the base (the plate) and held out the actor to see whether she would spontaneously offer the base. Two of the three chimpanzees held out the base object at some point. But, crucially, none of these responses occurred spontaneously, and more importantly, in none of these responses was the holding out of the base accompanied by a look to E's face. A look to the partner's face while holding out the object is a key criterion of 'offering' used in all studies with human infants (Bates 1979; Camaioni 1993). Thus, in Tomasello & Carpenter's (2005) study, there was no indication that the chimpanzees offered the base to the human, and so there were no acts of role reversal.

An analogous study with human infants of 12 and 18 months of age was conducted by Carpenter *et al.* (2005). As in the study with the chimpanzees, situations were set up in which an adult did things like hold out a basket in which the infant was asked to place a toy. After the infant complied, in the test for role reversal, the adult placed the basket within the infant's reach and held up the toy herself. Impressively, even some of the 12-month-olds spontaneously held out the basket for the adult while at the same time looking to her face, presumably in anticipation of her placing the toy inside. Thus, the infant's handing behaviours, in contrast to those of the chimpanzees, were clearly acts of offering learned through role reversal.

It thus looks as though chimpanzees, in contrast to young human children, do not fulfil either of the first two criteria of cooperation: sharing a joint goal and understanding the roles of a joint activity in some general way. The third criterion is that, if needed, the partners of a joint cooperative activity help one another do their part successfully. In two recent studies, chimpanzees did not take an opportunity to 'help' another individual obtain food (Silk *et al.* 2005; Jensen *et al.* 2006). But food is a resource over which apes used to compete, and so maybe helping is better investigated in situations that do not revolve around food. Given our interest in helping as a constituent of cooperation, the most important form of helping is 'instrumental helping', in which one individual helps another instrumentally to achieve a behavioural goal. We know of only one study investigating instrumental helping in non-human primates. Warneken & Tomasello (2006) had three human-raised juvenile chimpanzees watch a human attempt, but failed to achieve different kinds of individual goals. Reasons for her failure were that her desired objects were out of reach, that she ran into physical obstacles or clumsily produced wrong results, or used ineffective means. The chimpanzees helped the human with some problems. However, the range of situations in which they helped was very limited: only when the adult effortfully reached and failed to grasp objects did the chimpanzees help her by fetching them for her.

An analogous study was conducted with 18 month old human infants, who also saw an adult fail to reach her goals for the same reasons (Warneken & Tomasello 2006). In this study, infants as young as 18 months of age helped the adult in various scenarios: for instance, they spontaneously removed physical obstacles that hindered the adult (e.g. they opened a cabinet so that the adult could place books inside) and showed him means that they knew were effective to bring about the intended result. It thus seems that, even though some helping behaviour can be found in non-human primates, only human infants display helping actions in a variety of situations, providing whatever help is needed in the given situation.

What we conclude from these experimental studies is that, despite their group hunting in the wild, chimpanzees do not have 'we-intentionality' (see Bratman 1992; Searle 1995; Tuomela 2002). They do not form a joint commitment to a shared goal and they do not perform reciprocal roles in the true sense as they do not generally understand both roles from a bird's eye view, in the same representational format.

Finally, they seem to be limited in their abilities to help another individual—which is a necessary prerequisite to engage in cooperative activities narrowly defined. Human infants and young children, in contrast, have this we-intentionality and act cooperatively from at least 14 to 18 months of age. They 'remind' their partner of the joint commitment to a shared goal, as they re-engage her when she suddenly interrupts the activity (Warneken *et al.* 2006; Warneken & Tomasello in press); they begin to reverse and understand roles as early as 12 months of age (Carpenter *et al.* 2005); and they help others in the fulfilment of their individual roles in various ways by at least 14–18 months (Warneken & Tomasello 2006, in press).

4. COOPERATIVE COMMUNICATION

A related domain, which also requires some form of cooperation is communication. As noted above, chimpanzees usually perform poorly in experiments that require some understanding of cooperative communication. Here, we address this issue in more detail by first looking at non-human primates' own production of communicative gestures, and then at their comprehension of such gestures produced by others.

Chimpanzees gesture to one another in different contexts. Some of these gestures are clearly intentional, in the sense that they are not just triggered by certain environmental conditions, but used flexibly to do such things as elicit play in the other (by an 'arm-raise') or to request nursing (by a 'touch-side'). That these gestures are indeed used flexibly is illustrated by a number of phenomena, for instance, the fact that visual gestures are only used in instances in which the recipient is visually oriented towards the sender (e.g. Tomasello *et al.* 1997*b*; Kaminski *et al.* 2004). One might think that if chimpanzees can gesture flexibly and understand some things about visual perception (see §2) they should also use gestures to direct another chimpanzee's attention to a certain event or object by pointing. There are certainly occasions in which it would be very helpful if one ape pointed for another ape to indicate the locus of some relevant event. It must therefore seem somewhat surprising that, in fact, there has not been a single reliable documentation of any scientist in any part of the world of one ape pointing for another. But captive apes which have had regular interactions with humans point for their human caretakers in some situations. Leavens & Hopkins (1998, 2005) conducted a study with chimpanzees in which a human experimenter placed a piece of food outside of the ape's reach and then left. When another human came in, the chimpanzees pointed to the food so that the human would get it for him (pointing was usually done with the whole hand, but some points were produced with just the index finger; see also Leavens *et al.* 2004). Human-raised chimpanzees have also been found to point to humans in order to obtain access to locations where there is food (Savage-Rumbaugh 1990), and some orangutans point for humans to the location where they can find a hidden tool, which they will then hopefully use to obtain food for the orangutans (Call & Tomasello 1994).

We thus find that apes do sometimes point for humans—given that they have had some contact with humans in the past. Importantly though, they use this manual gesture imperatively only. That is, they point for humans either in order to obtain a desirable object from them directly, as in the studies by Leavens & Hopkins (1998, 2005), or indirectly by requesting from the human to provide the necessary conditions for them to get the object themselves, as in Savage-Rumbaugh's (1990) study. It thus seems that what the apes have learned from their experience with humans is that the human will help them, and that they can use the pointing gesture instrumentally in order to make him help them. They thus 'use' the human as a 'social tool' in order to get things they otherwise could not get, and they have learned that pointing gets this tool to work (the term social tool was first used by Bates *et al.* (1975)). However, no ape has ever been observed to point for another ape or for a human declaratively—that is, just for the sake of sharing attention to some outside entity, or to inform others of things cooperatively, as humans often do. Liszkowski *et al.* (2004, 2006) have shown in a series of experiments that even when they first begin to point at around 1 year of age, human infants do this with a full range of different motives—including the motive to share attention and interest. In one study (Liszkowski *et al.* 2004), an adult reacted differently towards infants' points, and the infant's response to the adult reaction was investigated. The main finding was that if the adult did not jointly attend to the event with the infant (by alternating gaze between infant and event and commenting on it)—but instead either (i) just 'registered' the event without sharing it with the infant or (ii) only looked and emoted positively to the infant while ignoring the event—the infants were dissatisfied and tried to correct the situation. In contrast, in the joint attention condition, infants appeared satisfied with the response. Using the same basic methodology, Liszkowski *et al.* (2006) found that beyond the classic distinction of imperative and declarative pointing, 12 month olds point for others also to inform them about things that are relevant for them. In that study, they directed an adult's attention to the location of an object for which that person was searching. What this suggests is that in human ontogeny, pointing is used from the very beginning not just in order to obtain certain objects via helpful adults as social tools, but with the motivation to help/inform others or to just jointly attend to things in the world with them.

The question is thus why apes do not point to share interest and inform others as human infants do from very early in development (see also Tomasello 2006). They clearly have the necessary motor abilities to do so. And again, it would surely be useful if they spatially indicated important events for one another. So why do they not do it? To answer this question, one needs to look at apes' understanding of pointing. As mentioned earlier, one of the main paradigms that has been used to assess chimpanzees' comprehension of pointing is the Object Choice task. In the task designed by Tomasello *et al.* (1997*a*), one human, the hider, hides a piece of food for the ape in one of several containers. Then another human, the helper, shows the ape where it is by tilting the container so that she can look inside and see

the food. After this 'warm-up', the hider again places a piece of food in one of the containers, but now the helper indicates the location of the food for the ape by pointing at the baited container with his index finger (or by gazing at it). Variations of this method involve other kinds of communicative cues (Call & Tomasello 2005) and a trained chimpanzee instead of a human as the provider of the cue (Itakura *et al*. 1999). The results were the same in all these studies: the apes performed poorly, that is, they chose the correct container at chance level. They often followed the human's point (or gaze cue) to the container with their eyes, but they did not make any inferences from there about the location of food. That is, they cannot use or exploit the information that is conveyed to them via the pointing gesture—they do not know what it means. When following the human's point with their eyes, all they perceive is a useless bucket. To understand that the point is not directed at the bucket as such, but at the bucket qua location or qua container of a desired object, the apes would need to understand something about cooperation or communication. They would need to understand that the other is trying to communicate to them something that might be relevant for the achievement of their goal. In other words, an understanding of the meaning of the pointing gesture presupposes a more general understanding that others might want to help or inform us about things which they assume are relevant for our purposes. And this understanding obviously goes beyond the apes' social-cognitive skills.

The view that the challenge of the Object Choice task does indeed lie in its cooperative structure is supported by recent studies using a competitive version of the task. In one version, Hare & Tomasello (2004), instead of pointing to the baited container, reached unsuccessfully for it. Superficially, this reaching behaviour is very similar to the pointing gesture: the human's hand is oriented towards the container in which the food is hidden (the difference being that when pointing, only the index finger is stretched out, whereas in the case of reaching, all fingers point at the container). However, the chimpanzees' response in the reaching version was very different, as they successfully retrieved the food from the correct container. The reason for this must be that, even though the two tasks are superficially highly similar, their underlying structure is very different. Our interpretation is that in the case of reaching, the chimpanzees just need to perceive the goal-directedness of the human's reaching action and 'infer' that there must be something desirable in the container. This task can thus be solved with some understanding of the individual intentionality of the reaching action. In contrast, to understand pointing, the subject needs to understand more than the individual goal-directed behaviour. She needs to understand that by pointing towards a location, the other attempts to communicate to her where a desired object is located; that the other tries to inform her about something that is relevant for her. So the ape would need to understand something about this directedness towards itself ('this is for me!') and about the communicative intention behind the gesture in order to profit from it. Apparently, apes do not

understand that the cue is 'for them'—used by the other in a helpful, informative and communicative way. Even though they are quite skilful in understanding intentional behaviour that is directed at objects in the world (see Tomasello *et al*. (2005) for a review), they do not understand communicative intentions, which are intentions that are not directed at things or behaviours but at another individual's intentional states (with the embedded structure: 'I intend for you to know that I intend for you x').

In order to explain why the apes fail to understand communicative intentions, one needs to broaden the perspective and focus on what we call the 'joint attentional frame'. The joint attentional frame or common ground (Clark & Brennan 1991) is what gives a pointing gesture its meaning—it is what 'grounds' the communication in the shared space of meaning. To illustrate the point, imagine you are walking down the aisle of a hardware store and all of a sudden a stranger looks at you and points to a bucket standing in one of the shelves. You see the bucket, but, with a quizzical look on your face, look back at the stranger, because you do not know what is going on. The reason why you do not know what is going on is that you lack a joint attentional frame with the stranger, which would give the point its meaning. The pointing as such, in this frameless scenario, does not mean anything. But if, instead, you are walking down the same aisle with a friend because you are looking for a bucket to use for cleaning purposes, and your friend points out the bucket to you, you would know immediately what he means: 'Here is one!' The presence of the joint attentional frame, which could be described by something like 'we are searching for a bucket', grounds the point in the ongoing activity and gives it its meaning. Another possible scenario could be that you and your friend are looking for anything that is made of a certain kind of plastic because you like it so much. In this case, your friend's point would have a different meaning, namely something like: 'Here is an item which is made of that plastic that you like so much!' The referent of the pointing gesture thus varies as a function of the joint attentional frame in which the pointing is anchored. One can imagine an endless number of joint attentional frames for the same basic scenario, with the referents of the pointing gesture being, for instance, 'item with texture of kind x', 'item which is similar to that other item we just saw' and so forth. The pointing gesture does not just indicate some spatial location, but instead it already contains a certain perspective from which the indicated object or location is to be viewed. And the perspective is carried by the joint attentional frame.

Humans can read pointing gestures based on joint attentional frames from as early as 14 months of age. Behne *et al*. (2005) found that 14 month olds choose the correct container in the Object Choice task significantly above chance, thus demonstrating that they understand the pointing gesture cooperatively. Infants also know that the 'functioning' of a joint attentional frame is specific to those people who share it. Liebal *et al*. (in preparation) had 18 month old infants clean up with an adult by picking up toys and putting them in a basket. At one point, the adult

stopped and pointed to a ring toy, which infants then picked up and placed in the basket, presumably to help clean up. However, when the adult pointed to this same toy in this same way but in a different context, infants did not pick up the ring toy and put it in the basket; specifically, when the infant and adult were engaged in stacking ring toys on a post, children ignored the basket and brought the ring toy back to stack it on the post. The crucial point is that in both conditions the adult pointed to the same toy in the same way, but the infant extracted a different meaning in the two cases—based on the two different joint attentional frames involved, and the jointness is indeed a crucial component here. Thus, in a control condition, the infant and adult cleaned up exactly as in the shared clean-up condition, but then a second adult who had not shared this context entered the room and pointed towards the ring toy in exactly the same way as the first adult in the other two conditions. In this case, infants did not put the toy away into the basket, presumably because the second adult had not shared the cleaning context with them. Rather, because they had no shared frame with this adult, they seemed most often to interpret the new adult's point as a simple invitation to note and share attention to the toy.

We thus find that apes communicate individualistically, to get others to do things, and without joint attentional frames to ground the communicative intentions in a pre-existing space of shared meaning. Human infants, on the other hand, communicate cooperatively—to simply share interest in things and inform others of things—and they construct and participate in joint attentional frames, which give cooperative gestures their meaning, prelinguistically from as early as 14 months of age.

5. JOINT ATTENTION AND PERSPECTIVE

We thus find that human infants in their second year of life are much more skilled, and much more motivated, than are great apes at participating in collaborative problem solving and cooperative communication. Following Tomasello *et al.* (2005), our claim is that the reason for this difference is that human infants are biologically adapted for social interactions involving shared intentionality. Even at this tender age, human infants already have special skills for creating with other persons joint goals, joint intentions and joint attention, and special motivations for helping and sharing with others.

However, our claim goes further. Our Vygotskian intelligence hypothesis is that participation in interactions involving shared intentionality transforms human cognition in fundamental ways. First and most fundamentally, it creates the notion of perspective. Thus, consider how infants might come to understand that another person might see the same situation as they do, but from a different perspective. Just following someone else's gaze direction to another location is not enough. A difference in perspective can occur only when two people see the same thing, but differently (Perner *et al.* 2003). And so we would argue that young infants can come to appreciate that others see the same thing as they do, but from a different perspective only

in situations in which they first appreciate the sharedness of attention, the joint attention on a single thing and then note differences (see also Barresi & Moore 1996).

Evidence that infants as young as 12–14 months of age are capable of something in this direction comes from a series of studies in which infants must determine what an adult is attending to (and knows) in a situation in which gaze direction is non-diagnostic. Tomasello & Haberl (2003) had 12- and 18 month old infants play with an adult with two toys in turn. Before a third toy was brought out by an assistant, the adult left the room. During her absence, the infant played with the third toy together with the assistant. Finally, all three toys were held in front of the infant, at which point the adult returned into the room and exclaimed excitement followed by an unspecified request for the infant to give her a toy (without indicating by gazing or pointing which specific toy she was attending to). Surprisingly, infants of both ages selected the toy the adult had not experienced (was new for her). In order to solve this task, infants had to understand (i) that people get excited about new, not familiar things and (ii) which of the toys was new for the adult and which she was already familiar with from previous experience.

In this study, infants knew what was familiar for the adult because they had participated with her in joint attention around two of the objects (but not the third). This suggests the possibility that infants attend to and register another person's experience most readily when they are jointly attending with that person, and so the difference of others' attention to the infants' own attention is mutually manifest—the foundation of perspective. And this is what was basically found in the two studies by Moll and colleagues (Moll & Tomasello in press; Moll *et al.* in press). Following the basic procedure of Tomasello & Haberl (2003), 14- and 18 month old infants either (i) became familiar with the first two objects in a joint attentional frame together with the adult or (ii) simply witnessed the adult become familiar with the known objects individually. In each case, infants themselves became equally familiar with all three objects, as in the original study. The result was that infants knew which of the three objects was new for the adult and thus captured her attention only when they had explored the known objects in a joint attentional format with her (they could not make this distinction when they had just witnessed her exploring them on her own, outside of any joint attentional frame). Ironically, noticing that another person's attention to, perhaps perspective on, a situation is different from our own is achieved most readily when we share attention to it at the outset.

The notion of perspective—we are experiencing the same thing, but potentially differently—is, we believe, unique to humans and of fundamental cognitive importance. As we have previously proposed (Tomasello 1999; Tomasello *et al.* 2005), young children's participation in activities involving shared intentionality actually creates new forms of cognitive representation, specifically, perspectival or dialogic cognitive representations. In understanding and internalizing an adult's intentional states, including those directed towards her, at the same time she experiences her own psychological states

towards the other, the child comes to conceptualize the interaction simultaneously from both first and third persons' perspective (Barresi & Moore 1996)—forming a bird's eye view' of the collaboration in which both commonalities and differences are all comprehended with a single representational format. The cognitive representations underlying truly cooperative activities must thus contain both some notion of jointness and some notion of perspective. Such perspectival representations are necessary not only for supporting cooperative interactions online, but also for the creation and use of certain kinds of cultural artefacts, most importantly linguistic and other kinds of symbols, which are socially constituted and bi-directional in the sense of containing simultaneously the perspective of speaker and of listener (since the speaker is a listener; Mead 1934).

Perspectival cognitive representations pave the way for later uniquely human cognitive achievements. Importantly, following Harris (1996), Tomasello & Rakoczy (2003) argued and presented evidence that coming to understand false beliefs—the fact that someone else's perspective on things is different from what I know to be true from my perspective—depends on children's participation over a several year period in perspective-shifting discourse. In linguistic discourse—including such things as misunderstandings and requests for clarification—children experience regularly that what another person knows and attends to is often different from what they know and attend to, and the understanding of false beliefs—which, in almost everyone's account, is fundamental to mature human social cognition—is apparently unique to humans (Call & Tomasello 1999).

Perspectival cognitive representations and the understanding of beliefs also pave the way for what may be called, very generally, collective intentionality (Searle 1995). That is, the essentially social nature of perspectival cognitive representations enables children, later in the preschool period, to construct the generalized social norms that make possible 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 behaviour, this provides for a new kind of social rationality (morality) involving what Searle (1995) calls 'desire-independent reasons for action'. At this point, children have become norm-following participants in institutional reality, that is to say, fully functioning members of their cultural group.

Our argument is thus that the species-unique aspects of human cognition reflect their cooperative roots in fundamental ways. The ability to take the perspective of others—which spawns the understanding of false beliefs, perspectival cognitive representations and collective/institutional reality—is only possible for organisms that can participate in social interactions involving shared intentionality, especially interactions involving joint attention. Let us be very clear on this point. Participation in these interactions is critical. A child raised on a desert island would have all of the biological preparations for participation in interactions involving shared intentionality, but because she did not actually participate in such interactions, she would have nothing to internalize into perspectival cognitive representations. Ontogeny in this case is critical.

6. HUMAN EVOLUTION

The data reviewed here suggest that non-human primates and human infants share the ability to understand others as goal-directed, perceiving actors, and non-human primates display their skills most readily in competitive contexts. But human infants seem to display special skills and motivations in cooperative tasks involving shared intentionality—that is, those involving shared goals, joint attention, joint intentions and cooperative communication. Our proposal, the Vygotskian intelligence hypothesis, is thus that cooperation involving shared intentionality is a derived trait in human beings, emerging only after humans began down their own evolutionary pathway some 6 million years ago. This led to the emergence of cumulative cultural evolution as a process—involving various kinds of cultural learning and creation—and leading to the construction of all kinds of cultural artefacts, practices and institutions. It also led to the ability to create perspectival cognitive representations during ontogeny, which transformed human cognition from a mainly individual enterprise into a mainly collective cultural enterprise involving shared beliefs and practices, the foundation of cultural/institutional reality.

We do not have a detailed story of how skills and motivations of shared intentionality arose in human evolution. But, in general, to get from apes' skills of cooperation and social cognition to humans' skills of cooperation and social cognition evolutionarily, we think two key steps are needed. Three recent studies help to set the stage for this hypothesis.

— Melis *et al.* (2006*b*) tested chimpanzees in a simple collaboration task in which two individuals had to pull together to retrieve food. Whereas non-tolerant partners (as assessed in an independent test) cooperated very little, tolerant partners cooperated much better.
— Leavens *et al.* (e.g. Leavens & Hopkins 1998) documented that for a human, many captive chimpanzees point reliably to food they cannot reach, so that humans will retrieve it for them, even though they never point for conspecifics.
— Warneken & Tomasello (2006) found that young chimpanzees help human adults to retrieve out of reach objects—but not as often or in as many situations as 1 year old human infants.

These findings suggest that when they are interacting with especially tolerant and helpful partners—either conspecifics or humans—chimpanzees are able to behave in more cooperative ways. Hare & Tomasello (2004) thus proposed a two-stage theory of the evolution of human cooperation. First, some early humans had to become less aggressive/competitive and more tolerant/friendly with one another. One way to describe this process is a kind of self-domestication, in

which the more aggressive and less cooperative members of the group were somehow ostracized or killed. In this case, the remaining humans were then free to engage in all kinds of group activities, including group foraging and feeding, with less competition and aggression. The research cited just above suggests that in this new cooperative environment, new cooperative behaviours would emerge without any additional cognitive evolution (e.g. imperative pointing). Second, under the assumption that the first stage put our hominids in a new adaptive space of many friendly group activities, a second stage of selection could then have selected for individuals with especially powerful social-cognitive and -motivational skills for sophisticated cooperative activities involving shared intentionality. This second step would involve, especially, social-cognitive skills for forming shared goals, intentions and attention with others; for communicating cooperatively with others during collaboration and for helping others as needed in collaborative activities as well.

Whereas many previous accounts of the evolution of human culture, including our own, have emphasized the non-genetic transmission of skills and information across generations—via imitation and other forms of social learning—just as important are the cooperative group activities and communication in which much of human social interaction occurs, and in which many new cognitive skills are generated. If cumulative cultural evolution of the human kind requires faithful transmission in a kind of cultural ratchet across generations, it also requires innovations, and perhaps many such acts of cultural creation emerge from collaborative activities in which groups of individuals accomplish things that no one individual could have accomplished on their own. And these activities are of course made possible, in our account, by the ability to participate in and internalize social interactions involving shared intentionality, resulting in collective norms, beliefs and institutions.

7. CONCLUSION

The central question in the evolution of human beings' cooperative and cultural capacities and motivations is whether these could have evolved only through processes of individual selection, or whether, in addition, some group-level selection was involved as well. In the modern context, multi-level selection theories stress that the so-called 'strong reciprocity' could be the basis of human cooperative interactions (see Fehr & Gächter (2002) for a review), and this in the context of the so-called cultural group selection (Richerson & Boyd 2005). The intuitive appeal of these theories is that human cooperation seems to be something very different, and so it would not be surprising to discover that a slightly different set of evolutionary processes was at work. In any case, the data we have presented here will constrain any such theories by being specific about precisely how humans and their nearest primate relatives are similar and how they are different in the ways they collaborate, communicate and learn from conspecifics.

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