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Sylvia's recipe: The role of imitation and pedagogy in the transmission of cultural knowledge

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Historically, *imitation* has frequently been proposed as the central mechanism mediating the reproduction, spread, intergenerational transmission and stabilization of human cultural forms, population-specific behavioral traditions found in groups of non-human primates, or both (Baldwin 1894; Bandura 1986; Blackmore 2000; Byrne and Russon 1998; Dawkins 1976; Dennett 1995; Donald 1991; Meltzoff 1996; Tomasello, Kruger, and Rutner 1993; Tomasello 1999; Whiten 2000; Whiten and Custance 1996). In this paper we provide a critical reappraisal of the dominant role classically attributed to imitation in cultural reproduction.

We argue that the properties of alternative social learning mechanisms (such as emulation or imitation) reflect the specific demand characteristics that different kinds of cultural products impose on their cultural transmission process to ensure their reproducibility. We distinguish between cultural forms whose functionally relevant aspects are cognitively 'transparent' versus 'opaque' for the observational learner and discuss the inherent relation between these properties on the one hand, and emulation versus imitation on the other. We argue how the emergence of different cultural environments with predominantly cognitively transparent versus opaque cultural forms may have led to the selection and specialization of suitable alternative social transmission mechanisms.

Social transmission of behaviors in non-human primates

'Simple' (goal-driven) teleology and tool use in primates

Many field researchers (e.g. Byrne this volume; Byrne and Russon 1998; Boesch and Boesch 1993; Goodall 1986; McGrew 1996; Nishida 1987) have documented socially transmitted population-specific behavioral skills in primates (such as nut-cracking or termite fishing in chimpanzees, or manual techniques of leaf-gathering in mountain gorillas). It is possible that these behavioural skills involve no more than chance discovery and 'blind' associative processes resulting in habitual behaviour sequences leading to rewarding outcomes. However, there are several lines of evidence suggesting that these goal-directed and socially transmitted behavioural traditions are likely to involve a rudimentary understanding of at least some aspects of *teleological relations* (Gergely and Csibra 2003).

For example, from objects (such as sticks or stone flakes) scattered around a locally visible goal, primates seem able to pick and choose as their 'tool' the one whose physical properties seem most affordant to ensure goal-attainment. Similarly, apes can make simple functional modifications in the causal-physical properties of objects used as tools to make them more affordant in relation to the visible properties of a locally present concrete goal (Goodall 1986; Boesch and Boesch 1984; Tomasello and Call 1997).

Tomasello (1996) argues that during observing goal-directed object manipulations of other animals, apes can learn something about the physical affordance properties of objects.

Byrne (this volume) documented that mountain gorillas can learn relatively complex manual actions (leaf gathering skills) to achieve visible goals through observing others. He also reports spontaneous idiosyncratic, but functionally efficient variations of the modeled manual skills in animals crippled by snare wounds. These gorillas with severely maimed hands seem able to significantly modify the observed manual means actions in a functionally appropriate manner adjusting them to the morphological constraints of their hand deformities.

Non-human primates' teleological abilities are not restricted to tool use. Uller (2004) replicated with juvenile chimps the looking time results first demonstrated by Gergely et al. (1995) in human infants, showing the teleological ability to evaluate the relative efficacy of different means actions of another agent in relation to a visible goal. Tomasello et al. (2005) summarize a series of new studies indicating that chimpanzees have a rudimentary understanding of intentional actions of others in terms of goals and perceptions.

In sum: different lines of evidence converge to suggest a simple level of teleological understanding of means-ends relations in non-human primates. These include the comprehension of the relative efficacy of means actions of others as well as the relative degree of affordance of objects used as tools in relation to visible goals.

Cognitive limitations on non-human primates' simple teleology and functionalist understanding of objects as tools

Remarkable as it is, the level of teleological understanding exhibited by apes shows severe limitations when compared to the systematic inferential and predictive use of teleological reasoning in human infants (Csibra, Bíró, Koós, and Gergely 2003; Gergely and Csibra 2003) or, indeed, in comparison to the rather sophisticated functional understanding of tools and tool manufacturing and maintainance procedures of our hominid ancestors present, as evidenced by the archeological record, already roughly 2 million years ago[1] (Mithen 1996; Schick and Toth 1993; Semaw 2000).

1. *Non-human primates' teleo-functional conceptualization of objects as tools is activated by perceptual access to conrete goals at specific locations.* In apes teleological thinking about objects as tools seems induced only in the perceptual presence of specific and concrete goals that provide direct access to their affordance requirements (and when being in an unsatisfied motivational state to attain such goals). Importantly, to represent objects as tools by interpreting their causal-physical properties as affordances, it seems necessary for apes to have direct perceptual access to the relevant functional properties of the goal object. Their capacity to interpret physical object properties teleo-functionally as affordance properties seems, therefore, a transient and unstable conceptual ability that is triggered only under restricted and rather specific input conditions. It seems that only when these conditions are satisfied can primates evaluate objects from a functional point of view, choose and use them as tools, or modify their affordance properties functionally in relation to the visible properties of concrete goals.

2. *Lack of stable functional representations of objects as tools in terms of affordance properties.* These restricted input conditions on the activation of teleological thinking impose serious limits on the cognitive abilities of apes to functionally categorize and represent objects as tools. Such functional representations tend to be transient and local, involving only short periods of functionalist insight about objects as potential tools that is likely to be forgotten as soon as the goal is satisfied or abandoned, or the goal object is lost sight of. This is indicated by the temporally and locally restricted use of objects as tools by apes who tend to discard their tools after their goal has been satisfied and who

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[1] In fact, primate teleology seems limited also in comparison to the amazingly creative and generative - as well as causally sophisticated – innate teleological understanding of means-ends relations within the specific domain of tool use and tool making documented in the Caledonian crow (Kenward, Weir, Rutz, and Kacelnik, 2005).

(unlike our hominid ancestors) do not routinely keep, store, or carry tools for long distances with them. Similarly, while apes show some ability to functionally modify tools in the perceptual presence of a goal object, they hardly if ever make tools, modify their functional properties, or engage in maintainance activities in locations other than their direct application.[2]

3. *The goal concept of apes is restricted to objects that afford direct reinforcement.* Primates tend to interpret actions teleologically only in relation to specific types of goals that provide direct reinforcement such as food or sex. In contrast, the range and types of goals that human infants can attribute to actions is not tied to reward contents. In terms of the abstract representational and interpretive system of the one-year-old's 'teleological stance' (Csibra et al. 2003; Gergely and Csibra 2003), goals are identified and attributed to actions whenever efficiency considerations justify the actions as optimal means to achieve the goal in relation to the situational constraints of reality.

Demand characteristics of primate cultural traditions for social transmission mechanisms: Cognitive transparency and teleological emulation

The classical view among many primatologists has been that the existence of population-specific behavioral traditions in primate groups implies that these cultural forms are socially transmitted through imitation (e.g. Byrne and Russon 1998; Boesch and Boesch 1993; Goodall 1986; McGrew 1996; Nishida 1987). Several researchers pointed out, however, that the time it takes to learn population-specific traditions by individuals in ape or monkey communities turns out to be much longer than what would be expectable if the mechanism of transmission involved imitation. The same is suggested by the slow rate of spread of such behavioral routines within the population (see Galef 1990; Tomasello 1996; Tomasello and Call 1997; Visalberghi and Fragaszy 1990). These considerations (together with experimental difficulties in demonstrating clear-cut cases of imitative copying in primates, Call and Tomasello 1995; Tomasello and Call 1997) gave rise to the idea that instead of 'blind' imitation, the dominant social-cognitive learning mechanism mediating cultural transmission of primate traditions is some form of *emulation learning* (Tomasello 1996).

Tomasello (1996) proposed that emulation learning takes place when "by observing the manipulations of other animals individuals may learn all kinds of "affordances" of the environment that they would be unlikely to discover on their own" (p. 321). One of the important features distinguishing emulation from imitative copying is that in emulation learning the animal selectively attends to the interesting outcome (the concrete goal) that the other's manipulations bring about, while it apparently pays no attention to the particular behavioral means that the other performs to bring about the outcome. As Tomasello (1996) puts it, this kind of "social learning operate(s) without the individual organism paying any attention whatsoever to the actual behavior of other organisms" (p. 322). Having observed

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[2] We are aware that our current characterization of the types and range of restrictions that constrain primates' functional conceptualization of objects as tools may need to be qualified or tempered in the future as a function of increased availability of new and frelevant observational or experimental data. At present, however, we feel that the few sporadic and often anecdotal reports from field observations (see McGrew 2004, for a recent review) that may at first seem to contradict our generalizations can be easily accommodated by our hypothesis. For example, Boesch & Boesch-Ackermann (2000) describe evidence that in the lowland rainforest at Tai where quartzite stones used by apes to crack hard-shelled nuts are rare, chimpanzees do carry such stones to known source sites using a minimal distance strategy. Such a strategy, however, clearly implies prior perceptual access to the specific source location and the affordance requirements of the particular type of goal object (hard-shelled nuts) it contains: i.e., it is the animal's prior perceptual access to the specific goal information that precedes, triggers and directs the subsequent search for the nearest object with suitable affordance properties to be carried to the goal site for being used as a tool to attain the specific goal. No doubt this remarkable practice does imply the relatively short-term ability to mentally represent and actively maintain in working memory the previously perceptually accessed specific goal information that, nevertheless, acts as the initial triggering condition for the conceptualization of the stone object in terms of its relevant affordance properties.

the desirable outcome, the emulating animal tries to reproduce it on its own by applying the action schemes available in its motor repertoire to manipulate the tool and the goal object. Eventually, this process leads to success in finding and learning an efficient procedure that produces the outcome. This may happen either by rediscovering the same means action or manner of tool use that the observed model originally performed *or* by hitting upon some behavioral means other than the one observed, but that nevertheless also affords the attainment of the outcome. As a result, the degree of fidelity of cultural transmission of the observed skill is characteristically lower in emulation than what it would be expected if its reproduction were mediated by imitative copying.

The social reproduction of goal-directed skills in primates often produces relatively low-fidelity idiosyncratic variants of the actually observed actions that, nevertheless, retain their functional efficacy in relation to the goal. An intriguing example is the significant, but functionally appropriate modifications observed in the manual food-processing skills of mountain gorillas with maimed hands (Byrne this volume). Sumita, Kitahara-Frisch, and Norikoshi (1985), who looked closely at the spread of nut cracking in a captive group of chimpanzees, reported that even in normal primate populations many idiosyncrasies can be observed in the manner that different individuals perform nut cracking.

Nagel, Olguin, and Tomasello (1993) presented chimpanzees with a new rake-like tool being used by a human demonstrator either in a more efficient (up-side-down) or a less efficient (canonical position) manner to retrieve a small out-of-reach object. Instead of blindly imitating the model, these chimpanzees used the physically more efficient method in both cases independently of whether that means action had or had not been modeled to them (see also Call and Tomasello 1994).

Recently, Horner and Whiten (2005) provided evidence of rationally selective omission of irrelevant behavior by chimpanzees learning how to obtain a food reward by observing the actions of a model. These animals reproduced only the causally relevant behaviours from the sequence of actions modeled where some of these actions were functionally relevant while others were irrelevant for achieving the goal. Importantly, this rational teleological selectivity was observed only in one of the experimental conditions where – due to the use of a transparent plexy-glass box - the causal role mediating the effect of the actions inside the box was directly visible to them.

Above we argued that the characteristics of primate cultural tool-use, tool-modification, and production of goal-directed manual skills indicate some basic level of teleo-functional understanding of means-end relations in these animals. Now, given the variability of socially transmitted forms and their selectivity in relation to their causal and functional relevance reviewed above, we hypothesize that the kind of emulation mechanism that mediates the social reproduction of primate cultural skills is also based on and exploits the simple teleological understanding of visible means-end relations that primates possess. We shall refer here to this cognitively enriched notion of emulative observational learning as 'teleological emulation'.

Due to the cognitive constraints on primate teleology the behavioural traditions it creates are restricted to skills whose concrete goal is typically locally present and visually observable. This makes the means-end structure of the observed goal-directed manual skills and tool use cognitively 'transparent' for the primate learner in terms of his own simple teleological interpretive capacities. The demand characteristics represented by these cultural conditions of cognitive transparency favoured teleological emulation rather than blind imitation as the dominant social-cognitive learning mechanism specialized to mediate the within-group spread and intergenerational reproduction of primate cultural products.

In short, our proposal is that as long as the causal-physical and means-end structure of the cultural skills modeled are directly observable – and, therefore, cognitively transparent – to the primate learner, teleological emulation provides a sufficient social-cognitive transmission mechanism to ensure (and account for) the type of functionally relevant variability of transmitted contents that characterizes the relatively low fidelity cultural reproduction of primate behavioral traditions.

Can apes imitate, and if so, why don't they?

Given that, as the evidence suggests, primate behavioral traditions are culturally reproduced by teleological emulation rather than imitation, one may wonder (as many do) whether this is due to the fact that apes may simply lack the capacity to imitate. This seems *not* to be the case, however, as under some specific conditions apes can clearly be induced to imitatively copy the observed behaviors of others. There is certainly agreement that enculturated apes (like Kanzi or Chantek) brought up by humans (Call and Tomasello 1996; Tomasello and Call 1997) do learn to imitate at least some new behaviors demonstrated to them, though it is unclear which aspect(s) of their rich human cultural environment is instrumental in activating this otherwise practically dormant capacity. Recently, Horner and Whiten (2005) demonstrated experimentally that when observing a series of actions performed on a non-transparent box, chimpanzees blindly imitated a target action (poking a rod into the opaque box) when the potential causal role it may have played inside the box to release the food reward remained unobservable and therefore, not just physically but also cognitively 'opaque' to them. Importantly, in another condition where the causal-functional irrelevance of the very same action in attaining the food was clearly observable because the box was made of transparent plexy-glass (and so the chimpanzees could see that all the rod did was hit a barrier that was spatially separated from the location of the food and therefore it was clear that it played no causal role in releasing the food), the chimps selectively (and rationally) omitted this action from their subsequent attempts to get the food (but see Call and Tomasello 1995).

It seems therefore that apes do not simply lack the ability to imitatively copy observed behaviours[3], but that this capacity for blind imitation seems activated only under conditions of cognitive opacity of relevance of observed actions. This might explain then why in spite of being able to imitate, apes hardly ever do so during the social learning of the population-specific cultural skills they observe. In our view, this is so because the primate behavioral traditions present in their natural cultural environment typically involve perceptual access to visible goals and means actions whose causal-functional structure is therefore cognitively transparent to the observer's teleological understanding.

In sum: we have argued that while the conditions of cognitive transparency characteristic of the cultural traditions of primate groups activate teleological emulation as the dominant social-cognitive mechanism mediating their cultural transmission, imitation is a mechanism of social transmission that is specially suited for (and may be selectively triggered by) the demand characteristics of cultural environments that contain cultural products whose causal, functional, or intentional nature is cognitively opaque to the learner who can therefore only acquire them through imitative copying.

Demand characteristics of human cultural forms for social transmission mechanisms: Cognitive opacity and imitative learning

In contrast to population-specific primate traditions, it seems to be a central characteristic of human culture that many of its products are cognitively opaque to the learner in a variety of ways. As a consequence of this distinguishing feature, teleological emulation could not ensure the cultural transmission and maintenance of such human cultural forms that clearly necessitate the involvement of some form of imitative learning for their successful cultural reproduction.

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[3] In fact, 'blind' imitative behaviour copying seems to be a basic competence available to a variety of different species, sometimes used extensively and spontaneously in natural environmental conditions as in the case of vocal imitation in learning species-specific songs and dialects in psittacine birds such as sparrows (e.g. Petrinovich 1988), while in other cases experimentally inducible by presenting pre-trained conspecific models perform new behaviors that result in direct reinforcement, as in budgerigars, rats, or pigeons (see Heyes 1993; Galef 1995; Heyes and Galef 1996; Heyes and Dawson 1990; Galef, Manzig, and Field 1986).

Arbitrariness and conventionality of human cultural forms

The most obvious cases of cognitive opacity in human culture are provided by the *arbitrary* and *conventional* properties of most referential devises used in human communicative systems (such as words, symbols, or gestures). Such cultural forms could simply not be learned and culturally transmitted without relying on the learner's capacity to imitate. For example, the acoustic-phonetic features of most words of human languages necessitate imitative learning for their acquisition. It is clear that no teleological efficiency considerations of causal-physical affordance properties of phonemic strings could ever provide the learner with cognitive 'insight' into why a stone is referred to by the word 'stone' in English rather than some alternative phoneme string such as, say, the (Hungarian) word 'kő' that could (and, in fact, does) do the referential job equally well. Given the arbitrary relation between the conventional sign and its referent, the relevance of its culturally shared use is ensured by the conventionality of the linguistic form, rather than by its causal-physical affordance properties. The only way, therefore, that one can learn the vocabulary of the language of one's culture is through imitation, there is just no other way to do it.

Cognitive opacity and fidelity of cultural transmission: Sylvia's recipe

Maybe one of the most curious and hard-to-explain aspect of human culture is the sufficiently high-fidelity social transmission, and relative resistance to modification and change as a result of which many cognitively opaque cultural forms tend to be protected from the danger of entropy and eventual extinction from culture over the generations (Blackmore 2000; Boyd and Richerson 1985; Dawkins 1976; Dennett 1995; Sperber 1996, 2001, this volume). This seems true in the case of many human cultural forms in spite of (1) their cognitive causal or functional opacity to both their users and learners, as well as (2) their apparent lack of any clear locally adaptive value for the particular members of the culture using, transmitting, and maintaining them. This has certainly been a hot topic in the discussions of the role of imitation and other possible mechanisms ensuring the fidelity of cultural transmission and the stabilization of cultural forms in different models of cultural evolution (Boyd and Richerson 1985) such as memetics (Dawkins 1976; Dennett 1995; Sperber 1996), evolutionary psychology (Tooby and Cosmides 1992; Barrett, Dunbar, and Lycett 2002), comparative approaches to culture (Byrne et al. 2004; Whiten 2000) or cognitive cultural epidemiology (Sperber 1994, 1996; Sperber and Hirschfeld 1999, 2004) (for a recent review see Pléh 2003).

Let us illustrate this most important human-specific aspect of social-cultural inheritance by a (true) anecdote: The first author of this paper was having dinner with our friends the Watsons. During dinner, he told them about our new theory of the human-specific adaptation for 'pedagogy' that, in his view, could explain the curious characteristics of social transmission of relevant cultural knowledge in humans (see later). In the discussion that followed, Marilyn Watson (an educational psychologist, Watson and Ecken 2003) suddenly said "Well that makes sense of my colleague Sylvia's recipe for ham." She went on to relate this story. Sylvia, a fine educational researcher, was also a very good cook. She had a very special way of doing a ham roast. One aspect of her preparation was quite unique. She began by cutting a section off both ends of the ham. One day, while her elderly mother happened to be visiting, she set out to make her special ham for dinner. As her mother watched her remove the end sections, she exclaimed "Why are you doing that?" Sylvia said, "Because that's the way you always began with a ham." Her mother replied, "But that is because I did not have a wide pan!"

There are a few morals of this story we would like to call attention to: First, unlike her mother, Sylvia had plenty of large cooking pans that could easily accommodate even a pretty large ham in one piece. In spite of this, however, for many years she had continued to practice the habit of cutting off the two sidepieces of the ham before cooking it. (God knows, maybe her children are also doing the same today.) Second, she did so without ever spontaneously reflecting on the functional rationale (or lack of it) for this curious procedure that remained cognitive opaque to her during all these years. It was only by the happenstance of her mother's visit and comments that she came to possess a cognitive insight into this matter finally understanding (learning) what the original reason was for the cultural habit that she had (socially) inherited from her mother. Third, the specific habit survived in the family culture for all those years in this cognitively opaque form even though the conditions rationalizing the procedure as functional had long been absent.

Imitative learning as a human-specific adaptation of cultural transmission

Teleological emulation *versus* rational imitation: the selective interpretive nature of imitative learning in human infants

In a delayed imitation paradigm (Meltzoff 1988) demonstrated a novel goal-directed action to 14-month-old infants: the model illuminated a magic light-box by leaning forward from waist and touching the top panel of the box with her forehead. A week later, when given the chance to manipulate the box themselves, 67% of the infants re-enacted the novel ‘head-action’. No infants performed the ‘head-action’ in a base-line control group, however, who had not seen it demonstrated before. Meltzoff’s (1988) finding that 14-month-olds readily imitate the unusual and apparently less than optimal ‘head-action’ seemed rather unexpected from the point of view of our own theory of the one-year-old’s *teleological stance* or *naïve theory of rational action* (Csibra and Gergely 1998; Gergely and Csibra 2003). In a series of violation-of-expectation studies (e.g. Gergely et al. 1995; Csibra, Gergely, Bíró, Koós, & Brockbank, 1999; Csibra et al. 2003), we have shown that already 9- and 12-month-olds can attribute goals to observed actions and evaluate the efficiency of the means act in relation to the goal and the physical constraints of the actor’s situation. When seeing the goal and the actor’s situational constraints, these infants could infer – based on the principle of rational action – what the most efficient available means action to the goal would be *and* expected that the actor ‘ought to’ perform that particular means action (and not others) to achieve the goal (Gergely and Csibra 2003). On that ground, one would predict that in the Meltzoff (1988) task infants should perform the most efficient goal-directed action (the ‘hand-action’) available to them, instead of imitating the cognitively opaque and less rational ‘head-action’.

To clarify this situation, Gergely, Bekkering, and Király (2002) performed a modified version of the Meltzoff (1988) task. They hypothesized that "if infants noticed that the demonstrator declined to use her hands despite the fact that they were free, they may have inferred that the head action must offer some advantage in turning on the light. They therefore used the same action themselves in the same situation” (p. 755). To test this idea, Gergely et al. ran two groups of 14-month-olds varying the situational constraints under which the model demonstrated the very same ‘head-action’ to illuminate the magic box. In the ‘Hands occupied’ condition the model’s hands were occupied in a salient and natural manner when she performed the ‘head-action’. (She first pretended to be chilly and wrapped a blanket around her shoulders visibly holding it tight with both her hands, and only then did she bend forward to touch the box with her forehead). Another group of infants were tested in the ‘Hands free’ condition, where after pretending to be chilly and wrapping the blanket around her shoulders, the model liberated her hands and placed them visibly on the table at the two sides of the box. She then leaned forward and touched the box with her forehead. This ‘Hands free’ condition, therefore, basically replicated the original demonstration situation of the Meltzoff (1988) study where the model’s hands were also free.

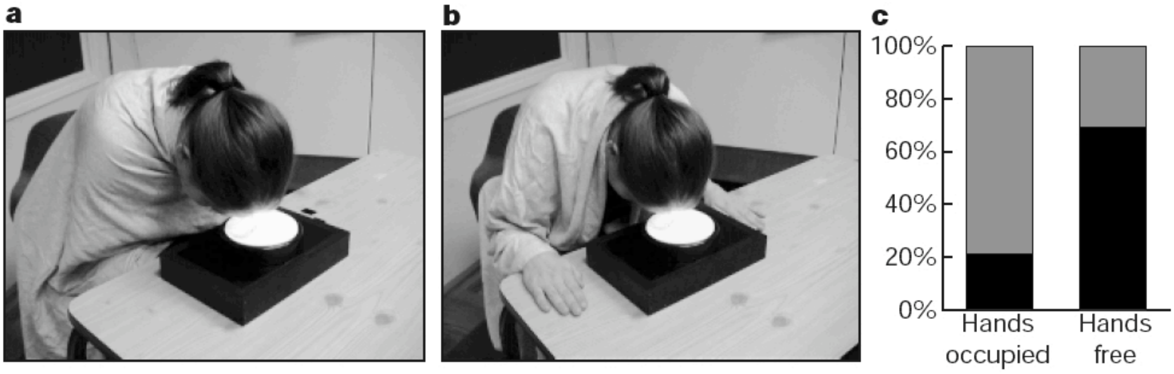

Figure 1

As Fig. 1 shows, when the model's hands were occupied, 14-month-olds were much less likely to imitate the 'head-action' (21%) when they returned a week after the demonstration. Instead, they illuminated the box by touching it with their hand (an emulative response), as this was a more rational/efficient means action available to them, but not to the model (teleological emulation). In contrast, when the model's hands were free, but in spite of this she still used her head to light up the box, the majority of the 14-month-olds (69%) imitated her 'head-action' replicating Meltzoff's (1988) original finding, (see Gergely et al. 2002).[4]

A further unexpected, but informative result of this study was that in *both* conditions *all* the infants tested performed the prepotent emulative 'hand-action' irrespective of whether they imitated the 'head-action' or not.[5] Moreover, all the infants in the 'Hands free' condition who imitated the 'head-action', did so only *after* they had performed the emulative 'hand-action' first that – in all these cases – actually succeeded in illuminating the box! In other words, even after they have experienced that the effect can be brought about by the simpler 'hand-action' as well, the majority of infants in the 'Hands free' condition were still motivated to re-enact the model's demonstrated – though less efficient – 'head-action'. This indicates that the novel response imitatively learned from the demonstration of a human model is retained by infants (even for several months, see Meltzoff 1995) in spite of the availability and production of more readily accessible and rational response alternatives that also produce the same effect. This clearly suggests that imitative learning of novel actions is a qualitatively different process in humans than the imitative copying of new and reinforcing behavior of observed conspecifics that has been demonstrated in several other animal species (see Heyes 1993; Galef 1995; Heyes and Galef 1996; Heyes and Dawson 1990; Galef, Manzig, and Field 1986) where the initially copied modeled response soon became extinguished when a more natural or equally or more efficient alternative action was available to the animal.

Cultural learning and human pedagogy

We shall now turn to our own interpretation of the nature of human imitative learning and its role in the transmission and maintainance of human cultural forms and knowledge. Earlier we argued that the demand characteristics of cognitively opaque cultural forms (a central feature of human culture) necessitate the recruitment of imitation as a social transmission mechanism to make the cultural reproduction of cognitively opaque aspects of cultural skills possible. However, the simple mechanism of blind imitative copying of observed actions is 'relevance-blind' as it cannot differentiate which are the (relevant) aspects of the observed behaviour that should be imitated and retained, and which are the (irrelevant) aspects that

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[4] We have also replicated this finding of selective imitation between the two context-conditions in a situation where the model was not present during the testing phase (Gergely, Király, and Koós 2003).

[5] Meltzoff (1988, 1995) presented only frequencies of imitating the target act and did not comment on the existence of alternative emulative responses such as the 'hand-action'.

should be selectively ommitted. Therefore, blind imitation – without any correction mechanism - would be a wasteful and error-prone social transmission process that would represent serious danger for the cultural and cross-generational survival of cognitively opaque human cultural forms (see Sperber's and Boyd's papers in this volume).

In our view, the capacity to blindly imitate observed behaviors of conspecifics is a cognitively low-level perceptual-motor mapping ability that is not unique to humans but is available to (and exploited in different species-specific adaptive ways by) a variety of non-human species as well. Imitation has, however, evolved to serve uniquely human functions as a component mechanism recruited by a complex cognitive system that we call human 'pedagogy' (Gergely and Csibra 2005a). We propose that human pedagogy is a primary species-specific cognitive adaptation to ensure fast, efficient, and relevance-proof learning of cultural knowledge in humans under conditions of cognitive opacity of cultural forms (Csibra and Gergely 2006).

In cultural learning one obvious way to overcome the limitations imposed by the cognitive opacity of relevance is to acquire the relevant knowledge content directly from another conspecific who already possesses it. As new behaviors, especially cultural activities, are often not transparent as to either their knowledge base or their function, an active communicative role of the more knowledgable conspecific may greatly assist the efficiency and viability of cultural knowledge acquisition. We propose (Csibra and Gergely 2006) that Mother Nature's 'trick' to make fast and efficient cultural trasmission of cognitively 'opaque' relevant knowledge possible was precisely along these lines: humans' have evolved complex and specialized cognitive resources – that we call 'pedagogy' – that form a dedicated communicative system in which the participants are inclined to teach and to learn new and relevant cultural information to (and from) conspecifics. In particular, we suggest that human individuals who possess cultural knowledge are naturally inclined not only to use, but also to ostensively *manifest* their knowledge to (and for the benefit of) naïve conspecifics, while the latter are naturally motivated to acquire such knowledge by actively seeking out, attending to, and being specially receptive to such communicative manifestations of knowledgable others. Through pedagogy, then, fast, efficient and 'relevance-proof' transfer of cultural knowledge – even when its content is cognitively 'opaque', arbitrary or conventional - becomes achievable.

Due to the design specifications of pedagogical knowledge transfer, the relevance of knowledge acquired is neither a (statistical) function of repetition of invariant contingencies and reinforcement, nor is it assured by innate triggering stimuli (as in imprinting), and is not guaranteed by innate content-fixation either (as in the case of evolutionarily selected pre-wired information structures). Rather, in pedagogy it is the very fact that a knowledgable conspecific (a 'teacher') ostensively communicates her cultural knowledge by manifesting it for the novice (the 'learner') is what ensures the (cultural) relevance of the knowledge content transmitted. Since the learner is predisposed to interpret ostensive communicative signals of the teacher as evidence for the novelty and relevance of the knowledge content manifested, this allows for fast learning of the knowledge communicated without any further need to test its relevance before acquiring it. Furthermore, since the relevance of knowledge in pedagogical transmission is presumed, it also allows for the acquisition of knowledge contents that are not only arbitrary, conventional, or functionally non-transparent, but that sometimes do not seem to (or actually do not) have any direct and perceivable adaptive value at all.

We further propose (Csibra and Gergely 2006) that the human-specific pedagogical inclination to teach each other (i.e. to transmit relevant and new information to conspecifics) is complemented by a special kind of human-specific receptivity to benefit from such teaching. Human infants are equipped with specialized cognitive resources that enable them to learn from infant-directed teaching: (1) they show very early sensitivity to *ostensive signals* that indicate teaching contexts (including eye-contact, contingent reactivity, infant-directed speech, and hearing one's own name), (2) they tend to interpret directional cues (such as gaze-shift or pointing) produced in pedagogical contexts as *referential actions* to identify the referents about which new information will be manifested, (3) they expect the 'teacher' to ostensively manifest by her behavioral demonstration the *relevant* and *new* information to be acquired about the referent, and (4) they are ready to *fast-map* such information to the object of reference (see Csibra and Gergely 2006, for a review of the developmental evidence supporting the very early presence of these capacities in infancy). Finally, the infant's 'pedagogical stance' contains the implicit assumption and expectation that the information revealed about the referents in such ostensive communicative teaching contexts will not only be new and relevant, but will consist of publicly shared and universal cultural knowledge that is, thus, generalizable and shareable with other members of the cultural community.[6]

Imitative learning in the service of human pedagogy: the role of ostensive-communicative cues

It is noteworthy that most developmental studies of imitative learning typically present their target behaviors in a rich ostensive pedagogical cuing context. For example, in a paradigm like Meltzoff's (1988), a model demonstrates the novel means action by first establishing eye-contact with the infant maybe also addressing him by his name (ostensive communicative cues), then she shifts her eye-gaze or points to the object to be manipulated (referential cues). This may be followed by an ostensive referential speech act (e.g. "Look, I'll show you something!") accompanied by knowing looks and smiling, and it is only then that the actual novel means act is manifested for the infant.

We hypothesize that in human infancy, initially, imitative learning is triggered (and certainly strongly facilitated) by the presence of such ostensive pedagogical cues that accompany the behavioral manifestations of relevant cultural information by others (Gergely and Csibra 2005a). Furthermore, we argue that the interpretive selectivity guiding what aspect of the modelled behavior is going to be imitatively learned is directed and constrained by the implicit assumptions of the infant's 'pedagogical stance' that the ostensive cues produced by the other activate in the infant. In particular, when taking the 'pedagogical stance', the infant interprets the ostensive cues addressed to him as indicating that the other is about to manifest 'for' the infant some significant aspect of cultural knowledge that will be new and relevant to him and that, therefore, should be fast-learned.[7]

Let us illustrate how human pedagogy works by applying it to the selective imitation finding of Gergely et al. (2002) (see also Gergely and Csibra 2005a). First, we assume that the 14-month-old interprets the ostensive cues of the model as indicating her communicative intent to manifest culturally relevant and new information for him to acquire. Second, this pedagogical cuing context induces in the infant a specific attentional and interpretive attitude that drives him to apply his existing knowledge structures and explanatory 'modes of construal' (Keil 1995, 2003; Kelemen 1999a,b; Gergely and Csibra 2003) to inferentially identify what aspect of the manifested behavior conveys new and relevant information to him. Third, the pedagogical cuing context triggers a special receptive learning mode in the infant to fast learn what he has inferred to be new and relevant information in the manifested action of the demonstrator.

Take the case of the 'Hands occupied' condition. Clearly, the novel outcome including the manifested affordance property of the object (it's illuminability upon contact) is new information previously unknown to the infant, so it is going to be retained in memory and

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[6] See Csibra and Gergely (2006) for additional arguments showing how a variety of early emerging social cognitive capacities – such as imitative learning (Gergely and Csibra 2005a) social referencing (Egyed, Király, and Gergely 2004), protodeclarative pointing, or word learning – can be usefully reinterpreted as examples of cultural learning through pedagogy.

[7] Note that these assumptions are directly analogous, if not identical, to the Gricean pragmatic assumptions of ostensive communication as spelled out in Sperber and Wilson's (1986) relevance theory. In our view, however, pedagogy is a primary adaptation for cultural learning and not a specialized module dedicated to the economic recovery of speaker's intent in linguistic communication that has evolved later as a sub-module of the general theory of mind capacity of humans (Sperber and Wilson 2002).

reproduced through action. But what about the particular behavioral means (the 'head-action') performed by the model to achieve the goal? Taking the teleological stance and relying on the principle of rational action (Gergely and Csibra 2003) the infant can infer that given the visible physical constraints on the actor (her hands being occupied), the act of touching the box by her forehead does, in fact, qualify as a sensible, justifiable, and physically efficient means action in this situation to bring about the goal. So, since the physical-causal efficiency of the 'head-action' is cognitively transparent (i.e. justifiable, expectable or even predictable given that the actor's hands are occupied), the fact that the actor used her head (and not her hands) to touch the box does *not* qualify as part of the new information that is being conveyed to him by the manifested action. Therefore, it is predicted that the infant is not going to imitate the 'head-action' in the 'Hands occupied' context condition, but will reproduce the novel information (i.e. will illuminate the box) by the most efficient means available to him given in his own situational constraints: she will use her (free) hand to light up the box (teleological emulation).

In the 'Hands free' condition the situation is clearly different, however. Of course, the novel goal involving the newly experienced affordance of the magic box is new information here, too, so it is going to be retained and reproduced. In contrast, when teleologically evaluating what the most efficient means action would be under the given situational constraints, based on the fact that the actor's hands were free to be used, the infant must have identified the available 'hand-action' as the most efficient (and, therefore, expectable) means that the model 'ought to' perform. Unexpectedly, however, the demonstrator chose not to use her free hands, but instead manifested the unusual 'head-action' to bring about the goal. We hypothesize that this perceived mismatch between the predictable and the actually performed means action "marked" the 'head-action' as also forming part of the new and relevant information that the other's ostensive manifestation conveyed. As a result, both the new goal and the new means were retained and imitated by the infant.

But is it really the case that the presence of pedagogical ostensive cues indicating a communicative intent by the demonstrator to teach are necessary to trigger the kind of inferences on the infant's part that can account for the selective imitation of the head action in the two context conditions? To find out we have recently run a new version of the Gergely et al. (2002) study. Half of the subjects were are presented with the 'head-action' in either the 'Hands free' or the 'Hands occupied' context conditions both introduced by the same pedagogical ostensive cues as before. The rest of the 14-month-olds participated in an 'Incidental Observation' condition in which they observed the very same 'head-action' performed in either the 'Hands free' or the 'Hands occupied' condition, but *without* being exposed to any ostensive-communicative cues by the model. Our findings (Király, Csibra, and Gergely 2004) show that the ostensive context does make a qualitative difference, as we have expected. In the 'Pedagogical cuing' situation we have replicated the very same pattern of selective imitation finding significantly more imitation of the 'head action' in the 'Hands free' than in the 'Hands occupied' conditions that was reported by Gergely et al. (2002). However, in the 'Incidental Observation' situation there was no significant difference in the degree to which the 'head-action' was imitated in the two context conditions. Furthermore, as predicted, in the 'Hands free' condition we found significantly more imitation of the 'head action' in the pedagogical ostensive cuing context than in the incidental observation condition (Király et al. 2004; Gergely and Csibra 2005a). Thus, the pedagogical cuing context proved necessary to induce the relevance-guided selective imitation of the 'head action' in the 'Hands free' condition. This pattern of results, therefore, provide support for our hypothesis that the presence of pedagogical ostensive cues play a central role in triggering the infant's interpretation of the model's behaviour as a communicative manifestation of relevant knowledge to be acquired.[8]

Finally, as argued in more detail elsewhere (Gergely and Csibra 2005a), it should be pointed out that neither the finding of relevance-guided selective imitation, nor the causal

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[8] For further supporting evidence of the influence of pedagogical cues in influencing the early teleo-functional construal of the function of new artifacts, see Casler and Kelemen (2005), and DiYanni and Kelemen (2005).

role that pedagogical ostensive cues play in inducing it seem easily accommodated by recent alternative theories of cultural learning that attribute a general innate tendency to human infants to imitate the observed actions of conspecifics that is driven by a species-specific drive to ‘identify’ with others who are recognized as “just-like-me” (Meltzoff 1996, 2002) or by a human-specific “motivation to share psychological states with others” (Tomasello, Carpenter, Call, Behne and Moll 2005)[9] with whome they identify. This is so because the presence of a human model – that would presumably automatically trigger identification in all of our conditions - would predict equal amount of imitation of the demonstrated novel ‘head action’ across conditions (“Hands free’ versus ‘Hands occupied’) and across presentation contexts (‘Pedagogical cuing’ versus “Incidental observation’) if “imitative learning…relie[d] fundamentally on infants’ tendency to *identify* with adults” (Tomasello 1999, p. 82; Tomasello, Kruger and Rutner, 1993), and if this human-specific motive for identification activated in infants a general “inbuilt drive to “act like” their conspecifics” (Meltzoff 1996, p. 363).

Where does cognitive opacity of cultural skills come from? A brief just-so-story

As our hypothesis asserts that pedagogy is a primary human-specific adaptation that does not necessarily rely on other (arguably human-specific) abilities like language or theory of mind (see Csibra and Gergely 2006), the question of evolutionary origin would inevitably be raised. How and why did pedagogy evolve?

We hypothesize that the conditions that represented selective pressure for the evolution of pedagogy may have first emerged due to qualitative changes in the forms of teleological reasoning about tools during hominid evolution that led to types of tool use and tool manufacturing practices that made them cognitively opaque for the observational learner. The simple goal-driven teleology of primates, as we argued, is severely restricted by being activated only in the presence of visible goals. When under these restricted input conditions, primates could confront the teleological question: “What object could I use to achieve this specific goal?”. We know though that our hominid ancestors have surpassed or qualitatively modified this simple teleology already some two million years ago, when they started to view the tools that they created as having permanent functions. As evidenced in the archaeological record, this new level of more stable teleological conceptualization of objects *as* tools was manifested in routine behaviours such as keeping tools instead of discarding them after use, storing them at specific locations, or pre-fabricating the tools at one location and carrying them for long distances for later application at a different place. We suggest that this momentous change in the application of teleological reasoning about tools required a *reversal of perspective* in the way our ancestors were thinking about tool-goal relations. Unlike simple primate teleology that could be only be triggered by direct perceptual access to a concrete goal, ‘inverse' teleological reasoning could be activated just by the sight of objects that were contemplated as potential tools even when no specific goal was present. In other words, the sight of an object itself (without the presence of a goal) could activate the question: "What purpose could I use this object for?"

Early hominids not only manufactured tools at a distance from their eventual functional use, they also used tools to manufacture other tools ('recursive' teleology) in the absence of visible goals. In both conditions the passive observational learner had no information about the relevant properties of the goal (that was mentally represented by the tool maker, but was visually inaccessible to the learner) that guided and constrained the tool manufacturing process. Therefore, the observed activity remained cognitively opaque for the learner as he had no basis from which to infer what were the relevant aspects of the observed activities that should be selectively retained and reproduced. Cognitive ‘opacity’, therefore,

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[9] For a critical analysis of this position, see Gergely and Csibra (2005b).

represented a serious *learnability problem* for previous forms of social-cognitive transmission mechanisms (including emulation) thereby endangering the cultural reproducibility of such new cultural practices.

We argue that the cognitive opacity of cultural products in early hominid cultural environments represented evolutionary pressure for the selection of a new type of social-cognitive learning mechanism to solve this learnability problem and to ensure fast and efficient transmission of culturally relevant knowledge.

So in our just-so-story it was the emerging cognitive 'opacity' of early hominid technological culture that eventually led to the selection of a human-specific communicative system specialized to ensure the intergenerational transmission of relevant cultural knowledge. This system, human pedagogy (Csibra and Gergely 2006; Gergely and Csibra 2005a), have provided a specialized cultural learning mechanism that made relevance-guided selective imitative learning possible. The mutual design specifications of pedagogy involve specialized cognitive resources on the part of both participants of the communicative process that ensure the efficient selective transfer of relevant cultural knowledge. On the one side, knowledgable humans ('teachers') became spontaneously inclined to ostensively communicate relevant cultural information by specific types of behavioral knowledge manifestations. These were designed 'for' the learner to guide and constrain his inferential attempts to identify from the communicative manifestation the new and relevant cultural contents to be acquired. On the other side, ignorant conspecifics ('learners') developed specific receptivity to pedagogical ostensive cues and knowledge manifestations and became equipped with specialized cognitive devices to infer and fast learn the relevant and new cultural information demonstrated 'for' them.

Human pedagogy as the evolutionary roots of human sociality

In conclusion, we speculate that human pedagogy – originally selected for the more restricted domain of hominid cultural learning – may have provided the basic phylogenetic roots for a much wider range and multiple forms of human sociality (Enfield and Levinson this volume). We suggest that the adaptation for pedagogy already (and maybe for the first time in evolution) exhibited some of the constitutive elements of human sociality as its mutual design features involve built-in assumptions (1) about the shared goal of both participants (being that of the transfer of relevant cultural knowledge) that forms the 'common ground' around which the pedagogical communicative exchange of relevant information is organized (see also Enfield, Clark, Tomasello, and Schegloff this volume), and (2) about the teacher's cooperative benevolence and communicative intent (Sperber and Wilson 1986) to share his culturally relevant knowledge with the learner.

References

Baldwin, J. M. 1984. *Mental development in the child and the race. Methods and process*. New York: Macmillan.

Bandura, A. 1986. *Social Foundations of Thought and Action: A Social Cognitive Theory.* Englewood Cliffs, NJ: Prentice Hall.

Barkow, J., L. Cosmides, and J. Tooby. 1992. *The adapted mind: Evolutionary psychology and the generation of culture.* New York: Oxford University Press.

Barrett, L., R. Dunbar, and J. Lycett. 2002. *Human evolutionary psychology.* Houndmills: Palgrave.

Blackmore, S. 2000. The power of memes. *Scientific American* 283(4):52-61.

Boesch, C., and H. Boesch. 1984. Mental map in wild chimpanzees: An analysis of hammer transports for nut cracking. *Primates* 25:160-170.

Boesch, C. and Boesch, H. 1993. Diversity of tool use and tool-making in wild chimpanzees. In *The Use of Tools by Human and Non-Human Primates*, edited by A. Berthelet and J. Chavaillon, 158-187. Oxford: Oxford University Press.

Boesch, C. and Boesch-Acherman, H. 2000. *The chimpanzees of the Tai forest: Behavioural ecology and evolution*. Oxford: Oxford University Press.

Boyd, R. and Richerson, P. J. 1985. *Culture and the Evolutionary Process*. Chicago: Chicago University Press.

Byrne, R. W., and A. E. Russon. 1998. Learning by imitation: A hierarchical approach. *Behavioral and Brain Sciences* 21:667-721.

Call, J. and Tomasello, M. 1994. The social learning of tool use by orangutans (*Pongo pygmaeus*). *Human Evolution* 9:297-313.

Call, J. and Tomasello, M. 1996. The effect of humans on the cognitive development of apes. In *Reaching into Thought*, 371-403, edited by A. E. Russon, K. A. Bard, and S. T. Parker. New York: Cambridge University Press.

Casler, K., and D. Kelemen. 2005. Young children's rapid learning about artifacts. *Developmental Science* 8(6):472-480.

Csibra G., and G. Gergely. 1998. The teleological origins of mentalistic action explanations: A developmental hypothesis. *Developmental Science* 1(2):255-259.

Csibra, G., and G. Gergely. 2006. Social learning and social cognition: The case of pedagogy. In *Progress of Change in Brain and Cognitive Development. Attention and Performance, vol. XXI*, edited by Y. Munakata and M. H. Johnson, 249-274. Oxford: Ofxord University Press.

Csibra, G., S. Bíró, O. Koós, and G. Gergely. 2003. One-year-old infants use teleological representations of actions productively. *Cognitive Science* 27(1):111-133.

Csibra, G., Gergely, G., Bíró, S., Koós, O., & Brockbank, M.1999. Goal attribution without agency cues: The perception of 'pure reason' in infancy. *Cognition*, 72:237-267.

Dawkins, R. 1976. *The Selfish Gene*. Oxford: Oxford University Press.

Dennett, D. 1995. *Darwin's Dangerous Idea: Evolution and the Meanings of Life*. New York: Simon and Schuster.

DiYanni, C., and D. Kelemen. 2005. Using a bad tool with good intention: How preschoolers weigh physical and intentional cues when learning about artifacts. *Cognition* 97:327-335.

Donald. M. 1991. *Origins of the modern mind: Three stages in the evolution of culture and cognition.* Cambridge: Harvard University Press.

Egyed, K., I. Király, and G. Gergely. 2004. Object-centered versus agent-centered Interpretations of referential attitude expressions in 14-month-olds. Poster presented at the 14th Biennial International Conference on Infant Studies, May 2004, Chicago, IL.

Galef, B. G. 1990. Tradition in animals: Field observations and laboratory analyses. In *Interpretations and Explanations in the Study of Behaviour: Comparative Perspectives*, 74-95, edited by M. Bekoff and D. Jamieson. Boulder, Colorado: Westview Press.

Galef, B. G., Jr. 1995. Why behaviour patterns that animals learn socially are locally adaptive. *Animal Behaviour* 49:1325-1334.

Galef, B. G., Jr., Manzig, L. A., and Field, R. M. 1986. Observational learning in budgerigars: Dawson and Foss (1965) revisited. *Behavioural Processes* 13:191-202.

Gergely, G., and G. Csibra. 2003. Teleological reasoning about actions: The naïve theory of rational action. *Trends in Cognitive Sciences* 7:287-292.

Gergely, G. and G. Csibra. 2005a. The social construction of the cultural mind: Imitative learning as a mechanism of human pedagogy. *Interaction Studies*, 6:3, 463-481.

Gergely, G., and G. Csibra. 2005b. A few reasons why we don't share Tomasello et al.'s intuitions about sharing. Commentary on Tomasello, Carpenter, Call, Behne, and Moll's target article 'Understanding and sharing intentions: The origins of cultural cognition.' *Behavioral and Brain Sciences* 28:701-702.

Gergely, G., H. Bekkering, and I. Király. 2002. Rational imitation in preverbal infants. *Nature* 415:755.

Gergely, G., I. Király, and O. Koós. 2003. Developmental changes in early observational Learning. Poster presented at the Biennial Meeting of the Society for Research in Child Development, April 24-27, 2003, Tampa, Fl.

Gergely, G., Z. Nádasdy, G. Csibra, and S. Bíró. 1995. Taking the intentional stance at 12 months of age. *Cognition* 56(2):165-193.

Goodall, J. 1986. *The Chimpanzees of Gombe: Patterns of Behavior*. Harvard University Press, Belknap Press, Cambridge, MA.

Heyes, C. M. 1993. Imitation, culture and cognition. *Animal Behaviour* 46:999-1010.

Heyes, C. M. and Dawson, G. R. 1990. A demonstration of observational learning using a bidirectional control. *Quarterly Journal of Experimental Psychology* 42B:59-71.

Heyes, C. M., and B. G. Galef. 1996. *Social learning in animals: The roots of culture*. New York: Academic Press.

Horner, V. and Whiten, A. 2005. Causal knowledge and imitation/emulation switching in chimpanzees (*Pan troglodytes*) and children (*Homo sapiens*). *Animal Cognition* 8:164-181.

Keil, F. C. 1995. The growth of causal understandings of natural kinds. In *Causal Cognition: A Multi-Disciplinary Debate*, 234–262, edited by D. Sperber, D. Premack, and A. J. Premack . Oxford: Clarendon.

Keil, F. C. 2003. Folkscience: coarse interpretations of a complex reality. *Trends in Cognitive Sciences* 7:368–373.

Kelemen, D. 1999a. Beliefs about purpose: On the origins of teleological thought. In *The Descent of Mind: Psychological Perspectives nn Hominid Evolution*, 278–294, edited by M. Corballis and S. Lea. Oxford: Oxford University Press.

Kelemen, D. 1999b. Functions, goals and intentions: Children's teleological reasoning about objects. *Trends in Cognitive Sciences* 12:461–468.

Kenward, B., Weir, A.A.S., Rutz, C., and Kacelnik, A. 2005. Tool manufacture by naive juvenile crows. *Nature* 433:121.

Király, I., G. Csibra, and G. Gergely. 2004. The role of communicative-referential cues in observational learning during the second year. Poster presented at the 14th Biennial International Conference on Infant Studies, May 2004, Chicago, IL.

McGrew, W. C. 1996. *Chimpanzee material culture: Implications for human evolution.* New York: Cambridge University Press.

McGrew, W. C. 2004. *The cultured chimpanzee: Reflections on cultural primatology*. New York: Cambridge University Press.

Mead, G. H. 1934. *Mind, self, and society*. Chicago: The University of Chicago Press.

Meltzoff, A. N. 1988. Infant imitation after a one week delay: Long term memory for Novel acts and multiple stimuli. *Developmental Psychology* 24:470-476.

Meltzoff, A. N. 1995. What infant memory tells us about infantile amnesia: Long-term recall and deferred imitation. *Journal of Experimental Child Psychology*, 59: 497-515.

Meltzoff, A. N. 1996. The human infant as imitative generalist: A 20-year progress report on infant imitation with implications for comparative psychology. In *Social learning in animals: The roots of culture*, edited by C. M. Heyes and B. G. Galef, 347-370. New York: Academic Press.

Meltzoff, A. N. 2002. Imitation as a mechanism of social cognition: Origins of empathy, theory of mind, and the representation of action. In *Handbook of Childhood Cognitive Development*, edited by U. Goshwami, 6-25. Oxford: Blackwell.

Mithen, S. 1996. *The prehistory of the mind*. London: Thames and Hudson.

Mithen, S. 2002. Mind, brain, and material culture: an archeological perspective. In *Evolution and the human mind*, edited by P. Carruthers and A. Chamberlain, 207-217. Cambridge: Cambridge University Press.

Nagell, K., Olguin, R., and Tomasello, M. 1993. Processes of social learning in the imitative learning of chimpanzees and human children. *Journal of Comparative Psychology* 107:174-186.

Nishida, T. 1987. Local traditions and cultural transmission. In *Primate Societies*, edited by B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham, and T. T. Struhsaker. University of Chicago Press.

Petrinovich, L. 1988. Individual stability, local variability and the cultural transmission of song in White-crowned Sparrows (*Zonotrichia leucophrys nuttalli*). *Behaviour* 107:208-240.

Pléh, C. 2003. Thoughts on the distribution of thoughts: memes or epidemics. *Journal of Cultural and Evolutionary Psychology* 11:21-51.

Schick, K. D., and N. Toth. 1993. *Making silent stones speak: Human evolution and the dawn of technology.* New York: Simon and Schuster.

Semaw, S. 2000. The world's oldest stone artefacts from Gona, Ethiopia: Their implications for understanding stone technology and patterns of human evolution between 2.6-1.5 million years ago. *Journal of Achaeological Science* 27:1197-1214.

Sperber, D. 1994. The modularity of thought and the epidemiology of representations. In *Mapping the Mind: Domain Specificity in Cognition and Culture,* 39-67, edited by L. A. Hirschfeld and S. A. Gelman. New York : Cambridge University Press.

Sperber, D. 1996. *Explaining Culture: A Naturalistic Approach*, Oxford: Blackwell.

Sperber, D. and Hirschfeld, L. 1999. Culture, Cognition, and Evolution, In *MIT Encyclopedia of the Cognitive Sciences*, cxi-cxxxii, edited by R. Wilson and F. Keil. Cambridge, Mass.: MIT Press.

Sperber, D. and Hirschfeld, L. 2004. The cognitive foundations of cultural stability and diversity. *Trends in Cognitive Sciences* 8(1):40-46.

Sperber, D., and D. Wilson. 1986. *Relevance: Communication and Cognition*. Oxford: Blackwell.

Sperber, D., and D. Wilson. 2002. Pragmatics, modularity and mind-reading. *Mind and Language* 17(1):3-23.

Sumita, K., Kitahara-Frisch, J., and Norikoshi, K. 1985. The acquisition of stone-tool use in captive chimpanzees. *Primates* 26:168-181.

Tooby, J. and Cosmides, L. 1992. The psychological foundations of culture. In *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*, 19-136, edited by J. Barkow, L. Cosmides, and J. Tooby. NY: Oxford University Press.

Tomasello, M. 1996. Do apes ape? In *Social learning in animals: The roots of culture*, edited by C. M. Heyes and B. G. Galef, 319-346. New York: Academic Press.

Tomasello, M. 1999. *The cultural origins of human cognition.* Boston, MA: Harvard University Press.

Tomasello, M., and J. Call. 1997. *Primate cognition*. Oxford: Oxford University Press.

Tomasello, M., A. C. Kruger, and H. H. Ratner. 1993. Cultural learning. *Behavioral and Brain Sciences* 16:495-552.

Tomasello, M., M. Carpenter, J. Call, T. Behne, and H. Moll. 2005. Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences* 28(5):675-691.

Uller, C. 2004. Disposition to recognize goals in infant chimpanzees (Pan troglodytes). *Animal Cognition* 7:154-161.

Visalberghi, E. and Fragaszy, D. M. 1992. Do monkeys ape? In *'Language' and Intelligence in Monkeys and Apes*, edited by S. T. Parker and K. R. Gibson. Cambridge University Press.

Watson, M., and L. Ecken. 2003. *Learning to trust: Transforming difficult elementary classroom through developmental discipline*, San Francisco: Jossey-Bass.

Whiten, A. 2000. Primate culture and social learning. *Cognitive Science* 24:477-508

Whiten, A., and D. Custance. 1996. Studies of imitation in chimpanzees and children. In *Social learning in animals: The roots of culture*, edited by C.M. Heyes and B.G. Galef, 347-370. New York: Academic Press.