To appear in: M.R. Banaji & S.A. Gelman, *Navigating the Social World: What Infants, Chidren, and Other Species Can Teach Us.* Oxford University Press.

Natural pedagogy

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While socially transmitted population-specific cultural skills exists both in human and non-human primate species (Whiten et al., 1999), the scope and kinds of cultural knowledge forms transmitted by humans suggests that our hominin ancestors may have evolved species-specific social cognitive adaptations specialized for cultural learning (Csibra & Gergely, 2006; Tomasello, 1999). There are a number of significant properties that differentiate the types of knowledge contents that are transmitted and maintained across generations in human cultures when compared to the much more restricted range of socially transmitted cultural skills that characterize non-human primate cultures.

First, human cultures are unique in that they involve the transmission of *cognitively opaque* cultural knowledge that is not (or not fully) comprehensible for the naïve observational learner in terms of their relevant causal and/or teleological properties. The variety of such cognitively opaque forms of cultural knowledge include relevant information about novel means-end skills and practical know-how embedded in relatively complex forms of tools use and tool manufacturing procedures, behavioural traditions that 'ought to' be performed in specific ways in particular types of social situations, normative conventions, shared knowledge about social rules and roles, or arbitrary referential symbols. Second, human cultures involve the transmission of *generic* (or semantic) knowledge of properties that specify and generalize to

kinds. Third, human cultures involve conveying *shared* cultural knowledge that is presumed to be equally accessible to all members of one's cultural group.

These three unique properties of human cultural knowledge forms would represent a serious learnability problem for naïve juvenile learners if they relied on purely observational learning strategies to acquire them from others. This is so because standard mechanisms of individual observational learning lack the appropriate informational basis that would allow the novice to (1) differentiate the relevant aspects of the observed but cognitively opaque behaviour (which should be selectively retained) from those that are incidental or non-relevant (and should therefore be omitted), (2) infer whether or how to generalize it to other situations, and (3) identify whether it represents shared knowledge that can be assumed to be available to other members of the cultural community as well (Gergely, 2010; Csibra & Gergely, 2009).

We hypothesized that this learnability problem would have endangered the successful intergenerational transmission of highly useful and fitness enhancing, but cognitively opaque technological skills that emerged during hominin evolution (Gergely & Csibra, 2005). In our view, this challenge represented selective pressure for a new type of social communicative learning mechanism, technically termed '*natural pedagogy*', to become selected in humans (Gergely & Csibra, 2006; Csibra & Gergely, 2006, 2011). Relying on ostensive-referential demonstrations of the relevant aspects of the opaque skills, communicative knowledge transfer could alleviate the learnability problem by having the knowledgeable conspecific actively guide the novice through selectively manifesting 'for' the learner the relevant information to be acquired and generalized. Thus, we propose that the mechanism of natural pedagogy is *ostensive communication*, which incorporates evolved interpretive biases that allow and foster the transmission of generic and culturally shared knowledge to others (Csibra & Gergely, 2006, 2009). Such communication is not necessarily linguistic but always referential.

There is extensive evidence that infants and children are especially sensitive to being

communicatively addressed by adults and that even newborns attend to and show preference for ostensive signals, such as eye contact, infant-directed speech or infant-induced contingent reactivity (Csibra, 2010). Such ostensive cues generate referential expectations in infants triggering a tendency to gaze-follow the other's subsequent orientation responses (such as gaze-shifts) to their referential target (Senju & Csibra, 2008; Senju et al., 2008; Deligianni et al., submitted; Csibra & Volein, 2008), which may contribute to learning about referential signals such as deictic gestures and words. We now know that human infants are prepared to being at the receptive side of verbal as well as pre-verbal communication from the beginning of their lives.

The most unique proposal of the theory of natural pedagogy is the hypothesis that the information extracted from the other's ostensive-referential communication is encoded and represented qualitatively differently from the interpretation of the same behaviour when it is observed being performed in a non-communicative context. In particular, infants have been shown to expect that (1) kind-relevant features of ostensively referred objects (such as their shape or texture) are more important to encode than their other properties that are not informative about and do not generalize to object kinds (such as their location, Yoon et al., 2008, or numerosity, Chen et al., 2011), (2) ostensively demonstrated functional properties of novel objects specify the artefact kinds they belong to (resulting in kind-based object individuation, Futo et al., 2010), (3) object properties revealed in ostensive communicative demonstrations are relevant to judging object categories (Kovács et al., 2011), (4) a novel means action should be learned despite it's apparent cognitive opacity as long as it has been communicatively demonstrated for them (Gergely et al., 2002; Király, 2009; Király et al., 2004), and (5) ostensive attitude expressions communicate shared cultural knowledge about referents (Gergely et al., 2007; Egyed et al., 2007). These effects suggest that infants assume that ostensive communication licenses certain inductive inferences that pure observation does

not allow them to make, and this assumption enables fast learning of culturally shared knowledge about object and action kinds.

Below we briefly address some of the most frequently asked questions about natural pedagogy in order to resolve some typical misunderstandings about what is and what is not claimed by our theory.

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Is natural pedagogy restricted to communication to children?

No. We believe that the interpretative biases that characterize natural pedagogy are essential constituents of human communication, and are perhaps derivable from general relevance-seeking mechanisms (Sperber & Wilson, 1995). In fact, recent evidence indicates that an ostensive communication automatically generates the same kind of genericity bias of referential interpretation in adults that has been demonstrated in infants (Marno et al., 2009). Nevertheless, it should be clear that novices, and especially infants and children, are the natural targets of relevance-guided teaching through natural pedagogy as they are most in need of acquiring a large amount of generic and shared cultural knowledge in a variety of epistemic domains, while they possess the least amount of background knowledge that could help them infer such cultural information from pure observation alone. Thus, we expect that cultural learning in young children would rely and depend on ostensively communicated information and relevance-guidance by knowledgeable and benevolent adults to a significantly larger degree than does cultural learning among adults. In contrast to infants and young children, adult cultural learners have access to a much larger variety of epistemic sources and can more competently employ inductive statistical learning and inferential reasoning processes that do not (and often need not) involve ostensive communication.

Does any kind of teaching count as an example of natural pedagogy?

No. We believe that natural pedagogy is a special kind of teaching that should be distinguished from many other behavioural skills that function to support and facilitate learning in naïve conspecifics, and, as such, can be also considered to fulfil the function of teaching (Caro & Hauser, 1992). Examples are conditioning, in which the teacher distributes rewards and punishments to the learner, or scaffolding (Wood et al., 1976), where the teacher modifies the learner's environment to promote individual learning (cf. opportunity teaching, Caro & Hauser, 1992). Several forms of teaching in this wider sense can be found both in human and in non-human species alike (Hoppit et al., 2008). However, we reserve the term 'natural pedagogy' to refer to instances of ostensive communication that promotes the learning of generic knowledge by the addressee.

Does the theory of natural pedagogy claim that adult communication to children primarily serves teaching functions?

No. Communication to children, just like communication between adults, serves various kinds of functions, which include supporting coordination of joint action and cooperation to achieve shared goals (Tomasello, 2008) as well as transferring relevant episodic information about individuals (Dunbar, 1998). However, infants and children seem prepared and, indeed, biased to acquire generic and culturally shared knowledge from ostensive communications of adults whenever the content of their communication enables such learning to occur. This propensity can, in fact, give rise to the potential of pragmatic misinterpretation of infant-directed communication especially at the early stages of development. For example, when adults attempt to play an episodic hide-and-search game with 10-month-olds (as in the classical Piagetian AnotB object search task, Piaget, 1954), the young infants who do not yet

understand the nature of the game, may mistake the adult's ostensive communications during object hiding actions as teaching events, and thus fail to encode the episodic information about current object location, which would be relevant for finding the object hidden, but irrelevant for learning anything generalizable about it. That such a pragmatic misinterpretation may, indeed, be induced by the adult's ostensive communication is suggested by our finding that when the object search task is presented *without* accompanying ostensive communicative gestures by the adult, young infants perform significantly better on the task showing a robust reduction of their characteristic perseverative search errors (Topál et al., 2008). Thus, children will have to learn the communicative and contextual cues that inform them about the episodic nature of instances of ostensive communication, making possible to inhibit their default tendency to interpret the content to be generalizable beyond the 'here and now.'

Does the theory of natural pedagogy claim that children acquire most of their generic knowledge through communication?

No. Inductive learning can be based on different kinds of information. For example, inductive generalization can be licensed by strong pre-existing biases built in by evolution as innate priors (such as fear of snakes) or by experience as acquired priors, or by statistical information accumulated over a longer period. Children are likely to learn the majority of their knowledge via individual learning, observational social learning, or overhearing. However, learning from communication becomes important for transmitting generic knowledge that has no pre-existing content bias, provides no frequent opportunities for statistical learning, and/or it's relevant aspects are cognitively too opaque to be properly identified and extracted through pure observational learning. In such cases, communicative support and ostensive referential relevance-guidance may be necessary to ensure fast and efficient cultural learning.

Can infants really comprehend the communicative intention in the ostensive acts addressed to them?

This, indeed, seems to be a necessary requirement for the system of natural pedagogy to work at early ages. When perceiving an ostensive cue, infants minimally have to be able to interpret it as indicating a second order intention referring to the presence of further signals that carry some communicative (and potentially, but not necessarily, pedagogical) content (Csibra, 2010). Such comprehension of ostensive acts does not guarantee that the infant will also be able to recover the content of the informative intent (cf. Sperber & Wilson, 1996, 2002) from the available signals, but it ensures that she will expect to find such relevant content. The assumptions that, according to the theory of natural pedagogy, infants adopt in searching for the content of the communication act as constraints on the hypothesis space for the inferential process that interpret infant-directed communication.

Is natural pedagogy human-specific?

It probably is. Animal communication is restricted to transmit only episodic information about particular referents, whose relevance is tied to the specific situational context of the 'here-and-now'. Non-human animals do not convey messages that are generalizable to different objects, locations, or situations. Although some species of non-human animals teach their young (in the wider sense of teaching, see Hoppit et al., 2008), they do not achieve this through transferring knowledge *by* communication (Csibra & Gergely, 2011). We believe that the reason for the absence of natural pedagogy in non-human animals is related to the fact that their behavioural repertoire, even when it incorporates local and socially transmitted traditions, does not include cognitively opaque elements that characterize many human instrumental actions and social conventions. Therefore, the social transmission of the

relatively small repertoire of such cognitively transparent cultural skills is sufficiently served by non-communicative observational learning mechanisms such as emulation (Tomasello, 1996).

Does dogs' sensitivity to human communication demonstrate an adaptation to natural pedagogy?

No. Dogs preferentially attend to human ostensive cues and learn to interpret referential signals, such as gaze, pointing, and words (Kaminski, 2009). They may expect to receive commands by human communication and by obeying them they can learn new routines. However, there is no evidence that they would generalize the content of single communicative acts as being relevant beyond the constraints of the 'here-and-now' to other objects or situations as human infants appear to do. For example, while they tend to make similar mistakes in the AnotB object search task as the perseverative search errors that is so characteristic of 10-month-old infants (Topál et al., 2008), the learning that underlies their errors is revealed to be closely tied to the local stimulus situation and even to the specific person demonstrating the hiding acts (Topál et al., 2009). This suggests that, although dogs have been adapted to interpret human communication signals, they expect that these signals express episodic imperatives for them to act in a certain way in the here-and-now rather than as conveying generalizable information about referents.

Is natural pedagogy universal across human cultures?

We believe it is. However, it should be noted that the theory we propose is about evolved cognitive mechanisms that enable the efficient transmission of certain types of cultural contents, rather than being about universal aspects of human behavioural forms across cultures that may, or may not, capitalize on these mechanisms. Nevertheless, we have found no convincing example of a human society in which verbal and non-verbal communication

would be used exclusively to convey episodic content (Csibra & Gergely, 2011). Undoubtedly, there are enormous cultural differences in how societies organize child rearing and how they ensure that children acquire the knowledge and skills they need. Considering the variability of relevant cultural and environmental factors, most importantly the extent of cognitive opacity of local traditions and artefact use, one should expect variable amount of reliance on communicative knowledge transmission across different cultural communities. This cross-cultural variability, however, should not conceal the fact that even the minimal amount of natural pedagogy that a child in a traditional society receives is much more than any non-human primate infant is subjected to (Csibra & Gergely, 2011).

Do children teach or just learn from teaching?

This is an empirical question. We have seen no convincing data on young (less than 4-year-old) children attempting to teach their generic knowledge to others by means of communicative demonstrations. We would not find it surprising if the application of natural pedagogy would be characterised by an asymmetry of developmental progression. If the function of such communication is the transmission of cultural knowledge, only children who have already acquired some of this knowledge would be expected to act in the role of a teacher. It is possible, however, that one could trigger productive communication of acquired knowledge even in younger children in certain situations.

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We have argued that during hominin evolution a specialized social cognitive system for 'natural pedagogy' has been selected to enable the intergenerational transfer of uniquely human forms of cognitively opaque, generic, and shared cultural knowledge whose

transmission would have posed a learnability problem for purely observational learning mechanisms. Natural pedagogy recruits *ostensive communication* to support inferential learning of such cultural contents from infant-directed manifestations provided by knowledgeable conspecifics. Ostensive signals induce built-in cognitive biases of referential interpretation (such as the genericity bias) that support the transfer of generic knowledge about object and action kinds from communicative demonstrations through particular referents even in pre-verbal infants.

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