Marion Vorms
University College London
Department of Cognitive, Perceptual, and Brain Sciences
26, Bedford Way
London WC1H 0AP
United Kingdom
marion.vorms@ens.fr

A-not-B errors: testing the limits of natural pedagogy

Forthcoming in Review of *Philosophy and Psychology*. Penultimate draft.

Acknowledgements

The author wishes to thank Gergely Csibra, György Gergely, Christophe Heintz, Pierre Jacob, as well as two anonymous referees, for useful comments and/or discussions on earlier versions of this paper.

A-not-B errors: testing the limits of natural pedagogy

Abstract: Gergely and Csibra's theory, known as "natural pedagogy", is meant to explain how infants fast-learn generic knowledge from adults. In this paper, my goal is to assess the explanatory import of this theory in a particular case, namely the phenomena known as "A-not-B errors". I first propose a clarification of natural pedagogy's fundamental hypotheses. Then, I describe Topál *et al.*'s (2008) experiments, which consist in applying natural pedagogy's framework to the A-not-B errors. Finally, I show that natural pedagogy, in its actual stage of development, does not suffice to choose between various interpretations of Topál *et al.*'s experimental results.

Keywords: *Natural Pedagogy; A-not-B tasks; Communication; Reference; Action; Learning.*

1. Introduction

Gergely Csibra and György Gergely's "natural pedagogy" theory (Gergely and Csibra, 2005, 2006, Csibra and Gergely, 2006, 2009, Gergely 2007) is a recently expounded explanatory framework in developmental psychology, which aims at accounting for cultural transmission. Natural pedagogy is hypothesized to be a human-specific cognitive adaptation, underlying infants' ability to fast-learn generic knowledge from adults. This theory is intended as an alternative to the various simulation-based accounts of cultural transmission (*e.g.*, Meltzoff 1996, 2002, Rizzolatti and Craighero 2004, Tomasello, 1999, Tomasello *et al.* 1993, 2005), which explain cultural learning, and particularly imitative learning, in terms of a cognitive adaptive disposition of infants to identify with others, and to "share" their psychological states.[1] Instead, natural pedagogy is hypothesized to be a "relevance-guided social communicative learning device" (Gergely 2007, 173). It is described as a human-adaptive disposition *a.* for experts (knowledgeable individuals, and more generally adults) to manifest generic knowledge, and prepare naïve conspecifics to receive it, and *b.* for naïve individuals (especially infants) to learn generic knowledge from experts. Gergely and Csibra claim that ostensive-communicative cues performed by an agent towards an infant induce a relevance-guided generalization process, which makes the infant interpret the information conveyed as generic, rather than as episodic information about a particular object or situation. This "genericity bias" thus serves an adaptive epistemic cognitive function, by enabling preverbal infants to "bridge the inferential gap from token to type" (Gergely 2010), namely extract generic knowledge from a single, non-linguistic communicative act.

Recent studies by Gergely and Csibra's group have applied this theoretical

[1] See Gergely (2007) for an analysis of these different accounts, and how natural pedagogy contrasts with each of them.

framework to various phenomena already highlighted and studied by developmental psychologists. These studies often consist in designing modified versions of paradigmatic experiments (in particular by varying the presence or absence of ostensive-communicative cues), and in predicting their outcomes on the basis of natural pedagogical hypotheses. Since these outcomes cannot be accounted for within the already existing developmental psychological theories, these experimental results are legitimately considered as providing evidence in favor of natural pedagogy. Yet, on its advocates' own admission, natural pedagogy does not provide a full-fledged explanation of all aspects of these results. Thus, the question arises whether it could provide such an explanation and stand against other existing proposals in developmental psychology as a self-contained alternative theory, in which case it needs further elaboration (as its advocates would certainly not deny). If not, then it needs to be articulated with already existing theories, which requires specifying exactly what its explanatory scope and limits are.

This paper intends to clarify the explanatory framework of natural pedagogy, and to address the question whether, and to what extent, this framework is compatible with other accounts of the same phenomena in developmental psychology. As a preliminary to such a clarification, this paper pursues a more restricted goal: it proposes a critical examination of the application of natural pedagogy to a particular phenomenon, known (since Piaget 1954) as "A-not-B errors". Topál *et al.* (2008) have indeed appealed to the explanatory framework of natural pedagogy in order to account for A-not-B errors. I shall argue that, while convincingly suggesting that A-not-B errors might be due in part to infants' pragmatic misinterpretation of the information conveyed by the experimenter, the advocates of natural pedagogy fail to specify exactly what this information consists of. In fact, several interpretations of the phenomena highlighted in Topál *et al.*'s experiments in terms of natural pedagogical hypotheses remain possible, none of which is fully satisfactory. Indeed, there appear to be partial inconsistencies in how natural pedagogy, and more particularly the "genericity bias" hypothesis, has been put to work for explaining different phenomena.

After briefly sketching the theoretical framework of natural pedagogy (section 2), I shall analyze how Topál *et al.* (2008) apply this framework to A-not-B errors (section 3). I will argue (section 4) that natural pedagogy, in its actual stage of development and conceptual articulation, does not suffice to choose between various interpretations of Topál *et al.*'s experimental results, although the design of these experiments and the prediction of their outcomes was prompted by the adoption of natural pedagogy's framework (and although other theories cannot account for these results at all). After reviewing some possible interpretations and highlighting the problems they raise, I sketch the design of some further experiments, which might help favoring one interpretation over the other(s).

2. Natural pedagogy's theoretical components

In this section, I first present the fundamental hypotheses of natural pedagogy, as expounded by its authors (Gergely 2007, Gergely and Csibra 2006, Csibra and Gergely 2006, 2009). Then, I briefly report some experimental results that were predicted on the basis of these hypotheses, and of which these hypotheses seem to be the best (existing) explanation. Finally, I emphasize one aspect of natural

pedagogy that will turn out to be of central importance for the rest of my analysis, namely that this theoretical framework is intended to account for infants' ability to fast-learn both knowledge about object-kinds (knowledge-that) and skills (knowledge-how).

2.1 Natural pedagogy's fundamental hypotheses

Gergely and Csibra's theory can be reconstructed as consisting of three distinct hypotheses.

2.1.1 First hypothesis: presumption of relevance in ostensive-communicative contexts

It is rather uncontroversial that infants are sensitive to ostensive behavioral stimuli, such as eye contact or special intonation ("motherese"). This is demonstrated by infants' significantly differential responses to imitation and violation-of-expectation tasks, depending on whether or not the habituation (or demonstration) phase has been run in an ostensive-communicative context.[2]

The first hypothesis of natural pedagogy is twofold. First, it claims that sensitivity to at least some ostensive signals, such as direct gaze towards the addressee, is likely to be innate (Csibra and Gergely 2006, 6; 2009, 149). One of the reasons[3] for such an assumption is that sensitivity to ostensive signals seems to be a prerequisite for pre-linguistic communication, and in particular for pedagogy, as conceived of by Csibra and Gergely: "these signals are essential for ensuring that the participants mutually recognize that they are in a teaching context" (Csibra and Gergely 2006, 6).[4] Indeed, the second part of (what I identify as) natural pedagogy's first hypothesis is that "ostensive cues directed at the infant learner trigger the automatic dispositional interpretation that their source agent has a *communicative intention* (addressed to the recipient) to manifest *new* and *relevant information* […] 'for' the infant to fast-learn" (Gergely 2007, 178). In other words, drawing from Sperber and Wilson's (1986) linguistic theory of relevance, and extending it to nonverbal communication, Csibra and Gergely claim that, in non-linguistic communicative contexts, ostensive cues enable the agent to communicate a "message destined to influence the targeted recipient but also the very fact that this message is being intentionally communicated to her" (Gergely and Csibra 2009, 149). Besides, ostensive cues trigger "a presumption of relevance", namely the disposition to interpret the message so conveyed as containing *novel* and *relevant* knowledge.

2.1.2 Second hypothesis: referential expectations

---

[2] Sensitivity to ostensive stimuli, as such, is not human-specific: dogs, who have co-evolved with humans, also respond differently in ostensive-communicative contexts, but this sensitivity is not interpreted, within the framework of natural pedagogy, as having the same function as in humans (see Topál *et al.* 2009).

[3] See also (Csibra and Gergely 2009, 149-150) for references to various experiments, including neuroimaging studies, which provide evidence in favour of the innateness of sensitivity to ostensive stimuli.

[4] "From an evolutionary point of view, the strong claim […] is that ostensive communication, which, according to several theorists, emerged before linguistic communication during human evolution, originally evolved to assist pedagogy." (Csibra and Gergely 2006, 6).

The production of ostensive behavioral cues is generally followed by referential behavioral cues (such as gaze-shift, head movement, pointing), which make it manifest that the agent has a communicative intention *about a referent*. There is experimental evidence that infants tend to follow the gaze of other persons only when gaze shifts are preceded by an ostensive signal, such as direct gaze.[5]

The second hypothesis of natural pedagogy is that "ostensive cues trigger an implicit expectation and attentional sensitivity to subsequent displays of *referential cues* […] that the infant is predisposed to attentionally follow in order to *identify the referent* about which relevant and new knowledge is expected to be manifested" (Gergely 2007, 178). Although referential communication is found in non-human animals too,[6] the specificity of human referential communication is that the agent specifies the referent *separately* from the message (Csibra and Gergely 2006, 6).[7] According to natural pedagogy, this is what makes it possible for humans to convey knowledge that is generalizable to other referents, even in nonverbal communication.

2.1.3 Third hypothesis: interpretation bias for generalizability ("genericity bias")

Learning implies the acquisition of information that can be re-used in other situations, rather than information obtaining only in the "here-and-now". But how can one learn *general* knowledge from a unique communicative event (or a short series of such events)? *Prima facie*, there seems to be no other way to transmit general knowledge than to express it through language. Instead, natural pedagogy suggests that the transmission of generic knowledge is not restricted to linguistic communication, and that a type of communicative learning system based on ostensive-referential demonstrations of knowledge was selected during hominid evolution.

Natural pedagogy's third hypothesis is that ostensive-communicative referential contexts put infants in a learning-situation, by modulating their interpretation of others' behavior. Such contexts do not only "make children pay more attention to the demonstration" (Csibra and Gergely 2009, 149); in ostensive-communicative contexts, children see the demonstration "as a special opportunity to acquire generalizable knowledge" (*ibid*), and they expect the information being conveyed to be *generic* (or *semantic*), rather than *episodic* information. Thus, natural pedagogy hypothesizes that infants have an innate disposition to interpret ostensive-referential communication as conveying information about a referent that is "*generalizable* to the object *kind* that the referent belongs to".[8] Hence, the

---

[5] See Csibra and Gergely (2009, 151) for references to experiments providing such evidence.

[6] As Csibra and Gergely (2006, 6) emphasize by referring to Seyfarth and Cheney (2003), "many examples of non-human animal communication are also referential".

[7] Here, the "strong evolutionary claim […] would be that the predicate-argument (knowledge-referent) structure of human communication pre-dates the emergence of language and originates in pedagogical communication" (Csibra and Gergely 2006, 6).

[8] The genericity bias hypothesis comes along with another one, which states that ostensive-referential cues trigger "the implicit expectation by the infant that the manifested information will contain *publicly shared universal cultural knowledge*

genericity bias allows even preverbal infants to extract generic knowledge about abstract types of referents from non-linguistic ostensive communicative acts "that can employ only deictic referential gestures (such as gaze-shift, body orientation, and pointing) that by necessity can identify particular referents only" (Gergely 2010).

2.2 Some experiments supporting natural pedagogy

Evidence from various experiments seems to confirm these hypotheses. One strategy of the advocates of natural pedagogy consists in running modified versions of classical developmental psychology experiments by varying the absence or presence of ostensive-communicative cues. Most often, classical experiments (such as violation-of-expectation or imitation studies) are run in ostensive-communicative contexts, since it is a good way to catch the infants' attention. However, it turns out that, when ostensive cues are removed, the modification of infants' responses cannot be accounted for merely in terms of a lesser attention on their part. Rather, the advocates of natural pedagogy claim that only their theory is able to predict infants' differential responses according to whether or not the experiment is run in an ostensive-communicative context. Let me briefly mention some examples.

A study by Gergely *et al.* (2007) highlights that infants (14-month-olds) interpret ostensive emotion displays (such as disgust) as valence information *about the referent* rather than as expression of the communicator's subjective attitude towards the object. Moreover, using the "object-requesting" paradigm first developed in (Repacholi and Gopnik 2007), Egyed *et al.*'s (2007) study contrasts 18-month-olds responses to others' emotion displays about objects according to the context (ostensive of not). The results show that, in non-communicative contexts, infants tend to interpret the emotion display as expressing the person's particular subjective preference, whereas the same attitude is interpreted as conveying generic valence information about the object in ostensive communicative contexts.

Yoon *et al.*'s (2008) violation-of-expectation study shows that 9-month-olds are more likely to detect the change of an object's *location* than of its *identity* in non-communicative contexts, whereas it is the other way around in ostensive-communicative contexts. Yoon *et al.* conclude that ostensive-communicative signals facilitate the encoding of enduring objects' features (here, their visual appearance) that are relevant for recognition and generalization, at the expense of transient objects' locations. In other words, ostensive-communicative cues do not help catching infants' attention *tout court*, but rather they prompt infants to attend to particular aspects of the object (*i.e.* its visual properties). On the other hand, in non-communicative contexts, infants pay more attention to the object's temporary location than they do in ostensive-communicative contexts.

2.3 Knowledge-how and knowledge-that. Natural pedagogy and the transmission of skills

---

available to all others (and not only to the demonstrator who is the communicative source of the information)" (Gergely 2007, 179).

Natural pedagogy's scope does not reduce to accounting for infants' disposition to fast-learn descriptive information about object-kinds or, so to speak, information about the state of the world ("knowledge-that"), but also for their disposition to acquire *skills*, such as, *e.g.*, opening a certain kind of container, switching on a certain kind of lamp ("knowledge-how"). In fact, natural pedagogy theory is grounded in a reflection on a species-unique characteristic of human cultures, namely the efficient and high-fidelity intergenerational transfer of various forms of cultural knowledge and skills that are "cognitively opaque" to their users and learners (see Gergely and Csibra 2006, Gergely 2007). These cultural forms include

> novel means-end skills and practical know-how embedded in relatively complex forms of tools use and tool manufacturing procedures, behavioral 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. (Gergely and Csibra, in press)

These cultural forms are cognitively opaque in the sense that they are "not (or not fully) comprehensible for the naïve observational learner in terms of their relevant causal and/or teleological properties" (Gergely and Csibra in press). For instance, the making and use of tools, and more generally of artifacts, are most often cognitively opaque, in the sense that they involve actions whose role in achieving the final goal is not transparent (see Csibra and Gergely 2006, Gergely 2007).

Gergely and Csibra take the transmission of cognitively opaque cultural contents as a challenge for any theory of early human social-cognitive development (Gergely 2007). And, by contrast with simulation-based accounts of cultural learning, which take *imitation* as the basis of the transmission of skills and knowledge, the advocates of natural pedagogy highlight the *relevance-guided* character of the transmission of knowledge and skills from experts to naïve conspecifics, in ostensive-communicative contexts. In a famous study on infants' imitation, Meltzoff (1988) had shown that 14-month-olds tend to reproduce a "novel means action", namely a unusual way of achieving a certain goal (such as switching on a light by using one's head, rather than one's hand), even when they had seen it performed only once before. Meltzoff, as well as other advocates of simulation-based accounts, such as Tomasello (1999), interpret these results in terms of the infants' identification with the agent, which makes them copy her action when they pursue the same goal as her (switching on the light).

The advocates of natural pedagogy, on the other hand, deny that infants would blindly replicate such a teleologically opaque action in any context. By varying some parameters of Meltzoff's original experiments, Gergely and Csibra's group has highlighted the determining role of the context in which the demonstration phase is run. First, Gergely *et al.*'s (2002) contrasted two different situations in the habituation phase. One was similar to Meltzoff's situation. In the other one, the agent, pretending to be chilly, covered her shoulders with a blanket that she held on to by her hands, thus having her hands already occupied while she intends to switch on the light. The results show that infants are much less prone to replicate the agent's exact action (switching on the light *with their head*) when the demonstration phase has been run in the "hands-occupied" situation. Hence, infants would only reproduce the teleologically opaque action if the demonstrator performs it in spite of the availability of a more efficient alternative, *i.e.* touching the bow with her hands. In fact, in the hands-occupied situation, the action is not

teleologically opaque anymore. Relying on their findings on teleological reasoning in infancy,[9] Gergely and Csibra suggest that, in the hands-occupied situation, the fact that the agent uses her head does not constitute any novel information; as a consequence, this sub-goal (using one's head) is not considered as relevant, and the infants reproduce the end (switch on the light), but not the mean (use one's head). On the other hand, in the hands-free condition, the agent's using her head represents novel information for the infants, and is thus contextually demonstrated as being the relevant information: "according to the infants' interpretation the relevant new information that the model's ostensive behavioral manifestation conveyed to them specified the particular *sub-goal* that they should achieve ("make the contact with the box by *using your head*!")" (Gergely 2007, 185).

Moreover, other studies (Gergely and Csibra 2005, Király *et al*. 2007) show that infants tend to reproduce the agent's teleologically opaque action only if the demonstration phase was run in an ostensive-communicative context: "the other's ostensively manifested new action induces a '*relevance-guided emulation*' by identifying the relevant *sub-goal — final goal structure* that the infant learner should acquire and realize." (Gergely, 2007, 186)

Hence, according to natural pedagogy theory, ostensive-communicative contexts trigger relevance-guided generalization of information in infants, and this information can be both *descriptive* information about an object-kind, and *normative* information about an action-kind (in a situation-kind). This will turn out to be of central importance for the analysis of section 4. For the moment, let me just raise the following question: Does the genericity bias work in a similar way in the two kinds of situation (transmission of knowledge-that and transmission of knowledge-how)?

3. Natural pedagogy and "A-not-B" tasks

Let me now focus on the application of natural pedagogy's explanatory framework to a famous phenomenon in developmental psychology, namely the phenomenon known as "perseverative search error" (or "A-not-B error"). After having briefly recalled what this phenomenon consists of, I will describe the

[9] Gergely and Csibra have proposed a non-mentalistic account of infants' understanding of goal-directed action (Gergely and Csibra 1997, 2003, Csibra and Gergely 1998). According to them, one-year-olds, although they are still unable to attribute intentional mental states to others, already possess a naïve theory of rational action. This enables them to represent, explain, and predict goal-directed actions by applying a non-mentalistic interpretational schema, which Gergely and Csibra have coined the "teleological stance". Such schema establishes a teleological (rather than causal) explanatory relation among action, future goal state, and current situational constraints. One point that calls for clarification, but which is much beyond the scope of the present paper, is how the teleological stance hypothesis articulates with natural pedagogy, which states that ostensive-communicative cues prompt infants to ascribe a communicative *intention* to agents. Is natural pedagogy committed to the assumption that ascribing a communicative intention is not part of mindreading?

experimental set-up designed by Topál *et al.* (2008), and assess their interpretation of the results.

3.1 A-not-B errors

First observed by Piaget (1954) in the context of the study of children's understanding of the physical world and of object permanence, A-not-B errors are mistakes performed by infants close to one year of age. The standard experimental setup highlighting these errors consists in a hide-and-search task, divided into two phases. During the first phase (habituation, or "A-trials"), the demonstrator repeatedly hides an object under one (A) of two containers (A and B) in full view of the infant, who is allowed to retrieve the object after each hiding event. After this habituation period, the demonstrator hides the object under container B (still in full view of the infant). During this second phase (test trials, or "B-trials"), infants frequently look for the object under container A. Piaget's original explanation of the phenomenon appealed to infants' supposedly incomplete understanding of object permanence. This explanation is now unanimously rejected, since there is strong evidence for object permanence in 2-month-olds (see Baillargeon 1994). Instead, several explanations have been proposed recently, appealing to deficits in inhibitory control over the (repeatedly induced) motor response involved in searching at location A, to constraints on short-term memory, to attentional biases, or even to motor simulation of the observed hiding action at location A through activation of the mirror neuron system (see Topál *et al.* 2008 for references). It is worth noting that most of the current explanations of A-not-B errors, if not all, suggest that this phenomenon has more to do with the development of *action*, rather than with the development of object representation.

3.2 Topál et al.*'s hypothesis and experiments*

As often, the strategy of the advocates of natural pedagogy consists in designing a modified version of the classical experimental paradigm (here, A-not-B tasks), by varying the absence or presence of ostensive-communicative cues, thus highlighting infants' differential responses depending on the context (ostensive-communicative or not). So far, indeed, A-not-B errors have always been highlighted in ostensive-communicative contexts.

Here, Topál *et al.* hypothesize that perseverative search error might (at least partially) be due to a *pragmatic misinterpretation* of the nature of the conveyed information. Because of the presence of ostensive-communicative cues, infants would interpret the situation as a teaching session, rather than as a hide-and-search game. As a consequence, instead of taking the conveyed information as episodic information about the particular location of the object in a particular game situation, infants, in ostensive-communicative contexts, would interpret the information conveyed during A-trials as generic information about the location appropriate to this kind of object. On this assumption, Topál *et al.* predict that infants' performance must be *better* in non-communicative contexts (their mistake rate must be lower), since, in such contexts, they are less likely to generalize information conveyed during A-trials.

Three groups of 10-month-olds are tested in three different contexts (see figure 1). In the ostensive-communicative (OC) context, the demonstrator establishes eye contact with the baby, and addresses him/her in infant-directed speech. In the non-communicative context (NC), the demonstrator does not look at the baby, her face and torso being 90° away from him/her. In the non-social context (NS), the

demonstrator is not visible by the child and acts from behind a curtain. Results show that infants are indeed more disposed to commit errors in OC (86%) than in NC (57%) and NS (64%) contexts. Note that, in the latter two contexts, infants still commit errors, but their search pattern appears to be random (their error rate is close to 50%).

As noted by Topál *et al*. (1833), none of the extant explanations of A-not-B errors (in terms of lack of inhibition of motor response or in terms of mirroring) is able to account for this "baffling tendency to perseverate" shown by infants in OC contexts. In fact, none of these explanations is able to explain the differences between the results in OC context on the one hand, and in NS and NC contexts on the other hand. Indeed, habituation trials in both OC and NC contexts provide infants with the same amount of motor and visual experience of the manual action towards container A. Therefore, Topál *et al.* conclude that infants' stronger disposition to commit A-not-B errors in OC contexts than in either NC or NS contexts supports natural pedagogy.

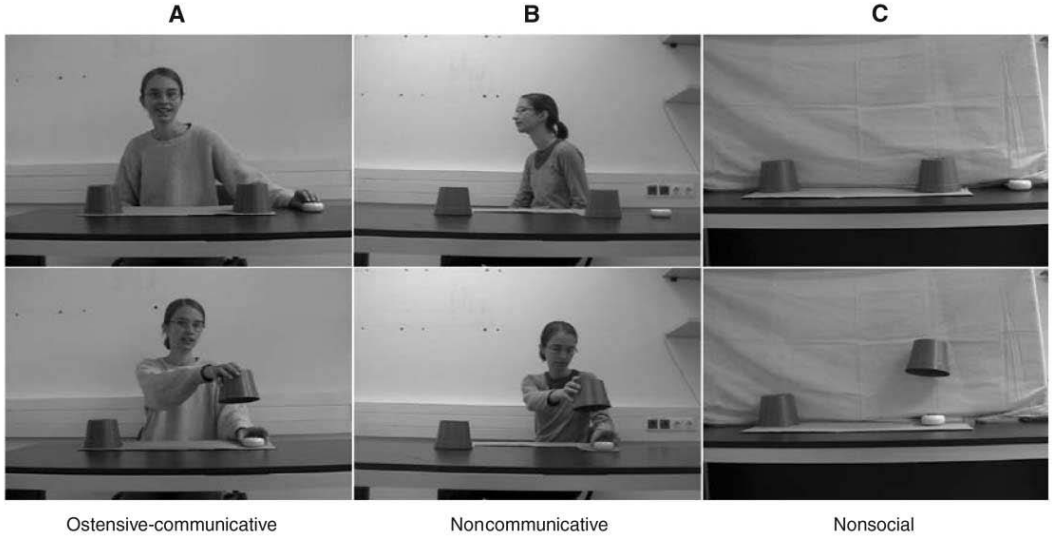

Fig. 1. Experimental arrangement in the three hiding contexts: (A) ostensive-communicative tasks, (B) non-communicative tasks, (C) non social tasks (Topál *et al.* 2008, 1832).

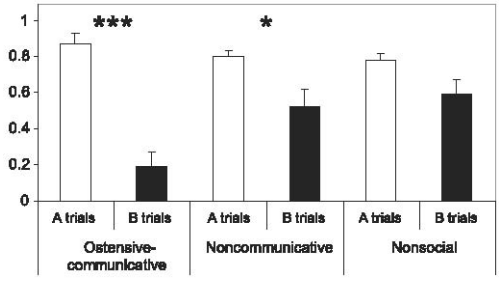

Fig. 2 Proportion of correct searches in A- and B-trials as a function of the hiding context (Topál *et al.* 2008, 1833). The magnitude of errors in B-trials is considerably smaller in the non-communcative and non-social conditions that in the ostensive-communicative contexts. In the latter two contexts, infants appear to search randomly under A or B, whereas they clearly perseverate in searching under A in ostensive-communicative conditions.

4. To what extent, and how, does natural pedagogy explain A-not-B errors?

Topál *et al*'s experiments certainly show that ostensive-communicative cues contribute to some extent to infants' perseverative errors. Moreover, interpreting the higher rate of errors in ostensive-communicative context as a result of some kind of "generalization" of information conveyed during the habituation trials seems plausible. However, as I shall argue now, various clarifications are needed before one can claim that natural pedagogy provides a full-fledged explanation of infants' perseverative errors. Since natural pedagogy alone is not sufficient to account for all aspects of the A-not-B errors, one needs to know whether and how this framework articulates with other existing accounts of this phenomenon. Moreover, one needs to spell out what kind of information is being generalized by infants in A-not-B tasks in order to provide a fine-grained description of their behavior in terms of natural pedagogy. For the moment, as I shall argue, various interpretations of Topál *et al.*'s experimental results are still possible, none of which is fully satisfying.

4.1 No explanatory framework alone is sufficient to account for A-not-B errors

First, it is worth emphasizing that the results of Topál *et al.*'s (2008) study demonstrate that removing ostensive cues in the A-not-B task does not result in eliminating infants' errors altogether. Rather, removing ostensive cues only eliminates infants' *perseveration*[10] in searching the object under the wrong container (*i.e.* container A), but this is not sufficient to induce correct searches: in both NC and NS contexts, infants search randomly (they perform approximately as many correct as wrong searches).[11] Hence, although natural pedagogy seems to offer a promising way to account for the difference between infants' search behavior in OC contexts on the one hand, and in NC and NS contexts on the other hand, it is not sufficient to explain all aspects of A-not-B errors (why do infants still commit errors in about 50% of the cases in NC and NS contexts). Rather, as Topál *et al.* themselves acknowledge, the significant rate of errors in NC and NS contexts shows that infants' search behavior calls for an explanation appealing to other cognitive factors, such as their "inhibitory, information processing, and memory skills" (Topál *et al*. 2008, p. 1833).

Insofar as Topál *et al.*'s main point is to show that natural pedagogy theory predicts the elimination of *perseveration*[12] (rather than of errors altogether) in non-communicative contexts, this does not challenge their conclusions. Their

[10] Perseveration corresponds to the cases in which the error rate is significantly superior to 50%. The distinction between perseveration (more than 50% of error) and random search (around 50%) only makes sense in the framework of natural pedagogy. Before Topál *et al.*'s (2008) experiments, A-not-B tasks were always performed in OC contexts, and the error rates were above 50% One of the arguments of Topál *et al.*'s against the existing explanations is precisely that they only account for random search, but not for perseveration.

[11] Thanks to Gergely Csibra (personal communication) for this clarification.

[12] See footnote 10.

results undeniably provide some evidence in favor of their hypotheses, since accounts that do not mention ostensive cues cannot explain at all the contrast between ostensive-communicative contexts and the other two contexts. Incidentally, this evidence is all the more striking so as these experiments show a "perverse" effect, so to speak, of ostensive cues: rather than helping infants in a learning process (as they are usually supposed to do), ostensive cues induce a misinterpretation of the game situation. However, acknowledging such a limitation in the scope of natural pedagogy raises at least two sets of questions.

First, it seems inaccurate to claim, as Topál *et al.* do, that their "results are not compatible with the current widely accepted explanations for the A-not-B perseverative bias" (Topál *et al*. 2008, 1833). Such explanations obviously cannot account for the reduced rate of errors in NC and NS contexts, but they might well be compatible with an additional explanation. Since, as Topál *et al*. acknowledge, natural pedagogy alone cannot itself account for A-not-B errors, one might ask the following questions: How does natural pedagogy combine with other explanations of the A-not-B error? Do ostensive-communicative contexts *amplify* the influence of the cause(s) (whatever it/they be) of infants' errors (in which case one has to clarify the interaction between these different causes)? Or do they *add* another cause to context-independent cause(s) that would act in parallel? This calls for clarification, in terms of how these possibilities could be empirically distinguished.

Second, it is not clear to what extent natural pedagogy provides an explanation of perseveration itself. Certainly, the hypothesis of a genericity bias in ostensive-communicative contexts (see section 2.1.3 above) is what prompted Topál *et al.*'s prediction of the reduction of error rate in NC and NS contexts. And it seems quite plausible that some kind of mistaken "generalization" of the information conveyed during the habituation trials might be the cause of the higher rate of errors in ostensive-communicative contexts. However, in order to provide a full-fledged explanation of perseverative errors (which, incidentally, might well help answering the questions raised in the previous paragraph), one needs more: one needs to understand how the explanation goes. One needs to know what information is being generalized, and how such generalization causes infants' perseveration towards container A. In other words, one needs a more fine-grained description of infants' cognitive processes in terms of natural pedagogy. In the following, I shall raise a few questions that need to be answered in order to work towards providing such a description.

4.2 What kind of generic information?

As explained in subsection 2.1, natural pedagogy states that ostensive-communicative contexts trigger infants' expectation to be taught *relevant* and *generalizable* information about a *referent*. It is not clear, however, what the referent is, and what generic or semantic information is in fact conveyed in Topál *et al.*'s experiments. Consequently, it is unclear how generalization of this information can explain infants' search behavior. *Prima facie*, one might think that the referent is the object being hidden, or rather the pair consisting of the object being hidden and the container, the information conveyed bearing on a certain relation holding between them. This is what Topál *et al.* (2008) suggest when they state that infants interpret the information as being "about some generalizable property of the referent kind (*e.g.*, "this type of object is usually

found in container A")" (1832). However, I see two difficulties with such an interpretation.

First, this interpretation does not seem to be fully consistent with Yoon *et al.*'s (2008) results (see above, subsection 2.2) according to which ostensive-communicative cues prime infants not towards location, but rather towards enduring features of objects. According to the interpretation just proposed, infants must focus on the location of the object in order to interpret the situation as a teaching session about *where* this type of object is usually found. Indeed, as far as I understand Topál *et al.*'s experimental setup, container A and container B are distinguishable from one another on the basis of their relative location only, rather than on any enduring visual feature. Hence, the information conveyed seems to bear on the *location* of the container where one usually finds this kind of object, rather than on the container itself (as member of a kind of objects). How can one accommodate this with Yoon *et al*.'s results? I shall come back to this problem in section 4.4.1.

Second, the description sketched above of what happens during habituation trials seems inaccurate. Indeed, the demonstrator does not merely draw infants' attention to the fact that the object is to be found under container A. This would be the case, for instance, if she uncovered the object *already placed under A*, or, better still, if she *pointed* at the object, before the container was placed upon it, preferably *by another agent*, thus restricting the demonstrator's ostensive action to pointing. But, in Topál *et al.*'s experiments, the demonstrator *performs an action*: she *hides* the object under A. Therefore, it seems plausible that the information that ostensive-communicative cues highlight as new, relevant, and generalizable, is (at least partially) *information about an action* rather than information about a permanent property of an object.[13] In the following, I will first give further arguments in favor of this interpretation, and show that it seems to be the one that fits best within natural pedagogy's theoretical framework (subsection 4.3). However, I shall argue that adopting this interpretation raises further problems, which need to be solved if one is to defend it.

4.3 Information about an action

Prima facie, the interpretation of infants' perseverative search errors as the result of a *pragmatic misinterpretation of information about an action* seems easy to accommodate within natural pedagogy's framework, and even to fit quite nicely into it. Indeed, as emphasized in subsection 2.3, natural pedagogy is meant to offer a framework for the transmission of both descriptive information (knowledge-that) about object-kinds and normative information (knowledge-how) about action-kinds. Although this interpretation (in terms of infants' pragmatic misinterpretation of information about an action) cannot be explicitly found in Topál *et al.*'s (2008) paper, it seems to be the one suggested by Csibra and Gergely (2009): according to them, one could interpret infants' perseverative

[13] This would be consistent with the nowadays widely shared assumption that A-not-B errors have to do with development of action, rather than with object representation. Indeed, as Carey and Spelke (1996) emphasize, children have been found to engage in A-not-B search patterns also when the object is visible (Harris 1994), as well as when they see motions of covers over potential hiding places containing no object at all (Smith and Thelen 1995).

errors as resulting from a "pragmatic misinterpretation of the experimenter's hiding actions as a communicative demonstration of some generalizable information" that could be stated so: "container A is 'for' storing the kind of objects being hidden" (Csibra and Gergely, 2009, 152). This statement could obviously be reformulated so: "one should generally store this kind of objects under container A".

In fact, in this case, it is even difficult to draw a clear-cut distinction between descriptive information about an object-kind (or rather two objects-kinds) and normative information about an action-kind: as György Gergely (personal communication) emphasized, when it comes to artifacts, descriptive information about the *function* of artifacts involves a normative dimension about how one should use it.[14] At least, information about an action has to be bound to something recognizable in order to know when to reproduce it: this can be a situation, a person, an object or, as seems to be the case in Topál *et al.*'s experiments, a pair of objects.[15] Hence, my proposition that information in Topál *et al.*'s experiments is information about an action *rather* than information about a permanent property of an object might be overstated. Moreover, as György Gergely (personal communication) highlights, there are at least two kinds of evidence showing that the identity of the object does matter in the A-not-B tasks. First, ostensive demonstration in Topál *et al.*'s experiments involves more than simply manifesting the action of putting an object under container A. The experimenter first demonstratively shows the object (moving it forth and back in the air, saying "look!" — ostensive "object-showing"). Second, there is empirical evidence for the importance of the object's identity: an old study (Schubert *et al.* 1978) shows that there is considerable reduction of error when the object changes from A-trials to B-trials. From such perspective, one might want to lessen the distinction I have proposed earlier between information about the pair "object-container" on the one hand and information about the action to be performed with this pair of objects on the other hand. Indeed, in such cases, descriptive statements about the function of (a kind of) object and normative statements about (a kind of) action can be considered as equivalent. One could thus conclude that the information being (mistakenly) generalized by the infants is about some *action related to an object*, or, rather, a pair of objects. However, even this interpretation, which I find the most convincing — and which, I believe, natural pedagogy's advocates would endorse[16] — raises further problems that I examine in the next subsection.

4.4 Further worries

4.4.1 The problem of location

Claiming that the information being generalized by the infants during the

[14] Futó *et al*. (2010) show that ostensive function demonstration induces kind-based identification of artefacts in infants. Hence, in such cases, normative information about an action-kind (how one should use a kind of object) is undistinguishable from descriptive information about some essential (*i.e.* kind-relevant) property about an object.

[15] Thanks to Gergely Csibra (personal communication) for drawing my attention to this.

[16] It seems correspond to what both Gergely Csibra and György Gergely suggested in their comments on an earlier version of this paper.

habituation trials has to do with an action, rather than (only) with an object, does not eliminate the first problem mentioned in section 4.2: this interpretation also seems inconsistent with Yoon *et al.*'s (2008) results. Yoon *et al*. have shown that ostensive cues prime infants towards *enduring visual features* of the objects than towards their temporary *location*. But how can one demonstratively perform the action of hiding an object without highlighting the temporary location of the object on which one acts, or more precisely the change of location of the object before its being hidden and after?[17] Whatever formulation one proposes of the information being supposedly generalized by infants, it seems that this information has to involve something about location A.

A first way to escape this problem might be to claim that, in some situations (in particular when the information conveyed is normative information about an action-kind), location could in fact be a relevant property. Obviously, what counts as a permanent, kind-relevant property, depends on the kind of objects at stake.[18] In the case of artifacts, whose relevant, kind-defining properties are bound to the actions one should perform with them, it might be that location — or, at least, a particular *movement*, which implies a *change in location* — is a relevant feature. Defending and articulating such hypothesis would however imply a reconsideration of the conclusions of the Yoon *et al.*'s study. It would also require clarifying the distinction between cases where the information conveyed is descriptive and concerns only object-kinds ("knowledge-that") from cases where it is normative and concerns also action-kinds ("knowledge-how"). In particular, one could ask whether the role of ostensive cues is similar in both cases.[19]

Another way to tackle the problem of the role of location in Topál *et al.*'s experiments might be to merely deny that the information being generalized imply any reference to location. In fact, in their review paper on natural pedagogy, Csibra and Gergely (2009) mention Topál *et al.*'s results as evidence *in favor of* the idea that ostensive cues prime infants towards enduring features of objects and away from their temporary location. The phenomena highlighted by Topál *et al.* would thus be a "perverse effect", so to speak, of ostensive cues on infants' understanding of the situation and attention focus:

> Under specific circumstances, however, this bias can give rise to erroneous *disregard of location information* [my emphasis] even in contexts (such as an object-hiding game) in which current object location happens to be the pragmatically most relevant information to

[17] Thanks to Pierre Jacob for highlighting this problem and urging me to tackle it.

[18] For studies about object-individuation tasks in infants, see Xu and Carey (1996), Xu *et al*. (1999), Xu (2007).

[19] Yoon *et al.*'s conclusions rely on a distinction between (ostensive) pointing towards an object (with no other action than pointing) on the one hand, and non-ostensive performance of an action towards the same object (reaching) on the other hand. Nothing is said about which features infants tend to memorize (temporary location or enduring visual properties) in the case of the *ostensive* performance of an action such as grasping (rather than merely pointing). However, in Topál *et al.*'s experiments (in the OC context), the experimenter performs two kinds of actions, so to speak: actions aiming at creating an ostensive-communicative context (such as addressing the baby by his/her name) *and* actions that can also be performed independently from the ostensive cues (hiding).

> attend to. We think that this is exactly what happens when infants display the well-known perseverative search error in the classical A-not-B task by trying to find a target object at a location where it had been hidden earlier (in container A) despite the fact that they have just seen it being hidden at a new place (in container B). This error shows that *infants ignore the new episodic information about the present location (B)* [my emphasis] of the object after having seen the adult repeatedly hide the object at a different location (A). (Csibra and Gergely, 2009, 152)

According to Csibra and Gergely, it is rather because they *ignore* the temporary location of the object in test-trials (B-trials) that infants fail in A-not-B tasks. But, as I understand this proposal, it still implies that infants have paid attention to and encoded information concerning the temporary location of the object during the habituation-trials (A-trials). What would explain such a difference of infants' attention between A-trials and B-trials? Or what is the information they have been generalizing during the A-trials?

The only way to make sense of this proposal so far as I can see — and, hence, to work towards escaping the problem of location — is to deny that the information being generalized during the A-trials involves location at all. Rather than information about the object being hidden under a container that stands in a certain *location* (A), infants would rather generalize information about the object being hidden under a certain *container* (A). Thus, they would learn something about the functional relationship between two kinds of objects (or, equivalently, about the appropriate action to be performed with these two objects), without any mention being needed of the location of these objects. In other words, infants would generalize information about the pair "object-container A", rather than about the pair "object-container standing on location A". Still, there remains a problem, already mentioned in section 4.2: as far as I understand Topál *et al*.'s experimental setup, the only feature enabling one to distinguish container A from container B is their relative location. Or are there further differences between the two containers that infants could encode as kind-relevant features? Or do infants "assume" that these two containers are of different kinds, without being able to isolate a particular kind-defining property? But then, again, what else but their relative location could enable infants to distinguish between them?

In order to work towards answering these issues, it might be useful to run A-not-B experiments along the lines of Topál *et al.*'s setup, but with two containers that would be distinguishable on the basis of their enduring visual features also (rather than only on the basis of their relative location). What would be the error rate of infants in such conditions? Would the difference between the proportions of correct searches in ostensive-communicative context on the one hand and in non-communicative and non-social contexts on the other hand be significantly different from what is the case in Topál *et al.*'s experiments? Moreover, in order to distinguish the role of the relative temporary location of the containers, on the one hand, and of their enduring visual features, on the other, one could also test infants' responses if the two containers (distinguishable on the basis of their visual features, *e.g.* their color) would be inverted between A-trials and B-trials.

I do not see any straightforward way to escape the problem of the role of location in Topál *et al*.'s experiments. The experiments I have just (roughly) suggested might shed some light on it, but probably not in any decisive way. In the rest of the paper, I shall ignore this problem and address further issues about the

interpretation of infants' behavior in Topál *et al*.'s experiments.[20]

4.4.2 What action does the information bear on? What is the task being performed by infants?

Leaving aside the problem of location, there remain further unsolved questions with the interpretation of the infants' behavior as the result of a pragmatic misinterpretation of information about an action. Most often, studies bearing on the transmission of skills (knowledge-how) involve *imitation tasks* (see subsection 2.3 above), where the children are supposed to reproduce an action performed by the experimenter. However, A-not-B tasks *are not* imitation tasks. In fact, there are *two different actions* involved: the demonstrator's and the infants' (hiding and searching). So what exactly is the action about which infants acquire general information? One could suggest that what they learn is something like: "This is where we normally put this (kind of) object, where it ought to be put". But this does obviously not correspond to the action they themselves are supposed to perform (both in the habituation and in the test trials). In fact, it is far from clear what task they are really performing.

As a consequence, it seems difficult to spell out how infants' generalizing some information about the experimenter's action influences their own performance. First of all, *can we assume that infants really aim to retrieve the object* that was hidden? What would warrant such assumption? Second, even if we do assume that infants' aim is to retrieve the object, are we entitled to conclude that their mistakes are due to their misrepresentation of the location of the object? If this were the case that they misinterpret the situation and fail to recognize it as a hide-and-search game, *why would they look for the object*? Moreover, if one admits that the information conveyed in A-trials involves some *normative* components about the appropriate action to perform (rather than being information about the usual location of this kind of object), one can suspect that it must influence infants' own performance in a different way, rather than merely modify their representation of the object's location. It must indeed tell them something about actions *to be performed*. Alternatively, are infants' wrong searches due to their misinterpreting the task they are supposed to perform (rather than to their misrepresentation of the actual location of the object)? Are they in some way trying to reproduce the experimenter's action, or to implement some kind of "*sub-goal — final goal structure*" (see above, section 2.3) — which they would have learnt during A-trials?

It seems that the very experimental setup of A-not-B tasks as such does not enable us to favor one of these interpretations over the others. One reason for this is that this setup involves elements having to do with (at least) three different things, namely action understanding, object representation, and action execution.[21] As a

[20] My hunch is that these different issues are not independent from one another, and have all to do with the role of action in the transmission of generic information, and with the relation between information about actions and information about objects in the theoretical framework of natural pedagogy (see footnote 19). This however needs to be elaborated.

[21] Moreover, making a choice among these various interpretations is all the more difficult so as ostensive cues only prompt infants' *perseveration*, but they are not supposed to explain infants' *errors* (as mentioned in section 4.1). Hence, it is

means to look for experimental evidence in favor of one or the other of the interpretations I have just sketched, it might help to run additional experiments, maybe by using a violation-of-expectation paradigm rather than a classical A-not-B task, where the infants have to perform an action. This would help distinguishing between the relative roles of action understanding, object representation, and action execution. A first set of experiments could test whether the experimenter's repeatedly hiding the object under A is more likely to prompt infants' misrepresenting the location of the objet during test trials in an ostensive-communicative context than in a non-communicative one. Instead of letting children *retrieve* the objects after each hiding event (in both habituation and test trials), one could just uncover both containers, and compare infants' looking times (both in ostensive-communicative and in non-communicative contexts) when the object is under A with their looking times when it is under B (this would require a trick enabling one to put the object under A in test trials without the infants' seeing it). Another set of experiments could test infants' surprise in front of *another agent* performing the A-not-B task (alternatively correctly and wrongly). This might help to clarify the respective role of infants' understanding of the goal they are expected to pursue (the goal of the game) on the one hand, and the difficulties associated with their actually executing an action towards this goal (it might reveal, for instance, a dissociation between their understanding and execution of their own action on the one hand and their understanding of others' actions).[22]

Before concluding, let me just add that these comments are not meant to deny that natural pedagogy offers a promising framework for explaining infants' perseverative errors in A-not-B tasks. Moreover, as both Gergely Csibra and György Gergely have suggested[23], there might not be one unique answer to the question of what exactly the content of the information being generalized by infants during A-trials is (it might depend on the available contextual information, and even on the individual subjects, their background knowledge, etc.). Nevertheless, I hope to have shown that there remain conceptual problems in the way the explanation of perseverative search errors in terms of a genericity bias can be articulated with other central claims of natural pedagogy. In particular, in addition to the problem of the role of location (section 4.4.1), it seems difficult to bring together the claim that infants misrepresent the task they are performing (by failing to recognize it as a hide-and-search game) *and* the assumption that they are really trying to retrieve the object. My suggestion is that these problems are (at least partially) due to the fact that nothing enables us to distinguish cases of knowledge-that transmission from cases of knowledge-how transmission. This makes it difficult to state what task infants are really performing, and, therefore, what their "mistake" consists in.

---

highly probable that causes of many different types interact here; that makes it even more difficult to spell out what role ostensive cues and infants' supposed genericity bias play here, and how they contribute to infants' behaviour.

[22] Thanks to Pierre Jacob for suggesting this.

[23] Both in personal communications and in an online discussion (http://www.cognitionandculture.net/PedagogyWeek/pedagogy-week-the-a-not-b-task.html).

5. Conclusion

Topál *et al*. (2008) show that ostensive cues influence infants' performance in A-not-B tasks by significantly increasing their error rates. As such, they undeniably provide evidence in favor of natural pedagogy. Whatever information is conveyed during habituation trials, one can legitimately claim that it is in virtue of their generalizing this information that infants perseverate in searching the object under A even during B-trials. However, I have shown that it is not clear how the genericity bias hypothesis can serve as a full-fledged *explanans* of perseveration, for we do not have yet a sufficiently fine-grained description of infants' behavior in terms of natural pedagogy. Working towards a more fine-grained description of the behavior of infants in terms of what information they generalize and what task they really perform seems an important project for at least two kinds of reason. First, since natural pedagogy alone is insufficient to account for all aspects of A-not-B errors and has to be combined with other explanations, one needs to clearly delineate how the explanation in terms of a genericity bias works. Second, when one tries to clarify how one could describe infants' behavior in Topál *et al.*'s experiments, it appears that various interpretations of these results are still possible, which seem sometimes at odds with other claims of natural pedagogy. Hence, on the conceptual side, some clarification is needed, which I suggest has mostly to do with the distinction between knowledge-how and knowledge-that transmission. On the empirical side, it might be worth designing experiments where the respective roles of action understanding, object representation, and action execution would be distinguished.

References

Baillargeon, R. (1994) A model of physical reasoning in infancy. In Rovee-Collier, C., and L. Lipsitt (eds), *Advances in Infancy Research*, vol. 9, Norwood, NJ: Ablex, 114-139.

Carey, S., and E. Spelke. (1996) Science and core knowledge, *Philosophy of Science*, 63:4, 515-533.

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

Csibra, G., and G. Gergely. (2006) Social learning and social cognition: The case of pedagogy. In Munakata, Y., and M. H. Johnson (eds), *Processes of Change in Brain and Cognitive Development (Attention and Performance*, *Vol. 21*) Oxford: Oxford University Press, 249-274.

Csibra, G., and G. Gergely. (2009) Natural pedagogy. *Trends in Cognitive Science*, 13:4 148-153.

Egyed, K. et al. (2007) Understanding object-referential attitude expressions in 18-month-olds: the interpretation switching function of ostensive-communicative cues. Poster presented at the Biennial Meeting of the SRCD, Boston, August 2007.

Futó, J., E. Téglás, G. Csibra, and G. Gergely. (2010) Communicative Function Demonstration Induces Kind-Based Artifact Representation in Preverbal Infants. *Cognition*, 117(1):1-8.

Gergely, G.and G. Csibra. (1997) Teleological reasoning in infancy: the infant's naive theory of rational action. A reply to Premack and Premack. *Cognition* 63, 17, 227-233.

Gergely G., and G. Csibra. (2003) Teleological reasoning in infancy: the naïve theory of rational action. *Trends in Cognitive Science*, 7(7), 287-292.

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

Gergely, G., and G. Csibra. (2006) Sylvia's recipe: The role of imitation and pedagogy in the transmission of cultural knowledge. In Enfield, N.J., and S.C. Levenson (eds), *Roots of Human Sociality: Culture, Cognition, and Human Interaction*, Oxford: Berg Publishers, 229-255.

Gergely, G., and G. Csibra. (in press) Natural pedagogy. To appear in M.R. Banaji and S.A. Gelman, *Navigating the Social World: What Infants, Chidren, and Other Species Can Teach Us.* Oxford University Press.

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

Gergely, G., Egyed, and I. Király. (2007) On pedagogy. *Developmental Science*, 10:1, 139-146.

Gergely, G. (2007) Learning 'about' versus learning 'from' other minds: Human pedagogy and its implications. In Carruthers, P. (ed), *The Innate Mind: Foundations and the Future*, Oxford: Oxford University Press, pp. 170-198.

Gergely, G. (2010) György Gergely on genericity, "Pedagogy theory week" series. International Culture and Cognition Institute website, http://www.cognitionandculture.net/workshops/pedagogy-week/715-gyoergy-gergely-on-genericity

Harris, P. (1974) The A/Not B error when object permanence is not at issue. *Journal of Experimental Child Psychology*, 18: 535-542.

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, USA.

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

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. (2002) Imitation as a mechanism of social cognition: Origins of empathy, theory of mind, and the representation of action. *In* U. Goshwami (ed.) *Blackwell Handbook of Childhood Cognitive Development,* Oxford: Blackwell, pp. 6-25.

Piaget, J. (1954) *The Construction of Reality in the Child*, New York: Basic Books.

Repacholi, B., and A. Gopnik. (1997) Early reasoning about desires: Evidence from 14- and 18-months-olds. *Developmental Psychology*, 33:1, 12-21.

Rizzolatti, G. and Craighero, L. (2004) The mirror-neuron system. *Annual Review of Neuroscience, 27,* 169-192.

Schubert, R.E., J.S. Werner, and L. Lipsitt. (1978) The Stage IV Error in Piaget's Theory of Object Concept Development: A Reconsideration of the Spatial Localization Hypothesis, *Child Development*, 49 (3), 744-748.

Seyfarth, R. M. and Cheney, D. L. (2003) Signalers and receivers in animal communication. *Annual Review of Psychology, 54,* 145-173.

Smith, L.B., and E. Thelen. (1995) Tests of a dynamic systems theory: The object concept. Symposium presented at the Meeting of the Society for Research in Child Development, Indianapolis.

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

Topál, J., G. Gergely, A. Miklósi, A. Erdhöhegyi, and G. Csibra. (2008) Infants' perseverative search errors are induced by pragmatic misinterpretation, *Science*, 321, 1831-1834.

Topál, J., G. Gergely, A. Erdhöhegyi, G. Csibra, and A. Miklósi. (2009) Differential sensitivity to human communication in dogs, wolves, and human infants", *Science*, 325, 1269-1272.

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

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

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

Xu, F. (2007) Sortal concepts, object individuation, and language, *Trends in Cognitive Sciences*, 11 (9), 400-406.

Xu, F. and S. Carey. (1996) Infants' metaphysics: the case of numerical identity *Cognitive Psychology*, 30, 111–153.

Xu, F. S. Carey, and J. Welch. (1999) Infants' ability to use object kind information for object individuation, *Cognition* 70, 137–166.

Yoon, J.M.D., M.H. Johnson, and G. Csibra. (2008) Communication-induced memory biases in preverbal infants. *PNAS*, 105, 13690-13695.