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Ready to Teach or Ready to Learn: A Critique of the Natural Pedagogy Theory

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Abstract: According to the theory of natural pedagogy, humans have a set of cognitive adaptations specialized for transmitting and receiving knowledge through teaching; young children can acquire generalizable knowledge from ostensive signals even in a single interaction, and adults also actively teach young children. In this article, we critically examine the theory and argue that ostensive signals do not always allow children to learn generalizable knowledge more efficiently, and that the empirical evidence provided in favor of the theory of natural pedagogy does not defend the theory as presented, nor does it support a weakened version of the theory. We argue that these problems arise because the theory of natural pedagogy is grounded in a misguided assumption, namely that learning about the world and learning about people are two distinct and independent processes. If, on the other hand, we see the processes as interrelated, then we have a better explanation for the empirical evidence.

Keywords: Natural pedagogy; evolution of teaching; children's learning; overimitation

1. Introduction

Theories of human uniqueness often point to some aspect of human social systems that seem to explain the vast differences between the human animal and all other species. Among these social explanations is the theory of natural pedagogy, according to which humans alone are teachers and students, expert humans are driven to actively teach naïve young, and the young are ready to learn from these interactions. While it may be true that humans are the only species that engage in active teaching (e.g., Caro & Hauser, 1992;

Csibra & Gergely, 2009; Thornton & Raihani, 2008), in this paper we argue that young children do not learn primarily through active teaching. Rather, children engage in active learning by deciding which models to imitate in order to gain knowledge about their physical world and the norms of their culture. To defend this claim, we argue that some of the evidence Csibra, Gergely and colleagues have proposed is better explained by the active learning alternative.

Here is the outline of this paper. First, in section 2 we present the basic tenets, the evolutionary story, and the primary merits of the theory of natural pedagogy. In section 3 we challenge three aspect of the theory: the evolutionary story, the domain generality of acquired knowledge, and children's acceptance of anyone who uses ostensive gestures as a model. Finally, in section 4, we examine some representative experiments used to support the theory of natural pedagogy, and offer alternative explanations for the data. We conclude by suggesting that though the theory of natural pedagogy could be modified in order to include some of our findings, such a modification would alleviate the need for the evolution of special purpose teaching adaptations.

2. Description of the theory of natural pedagogy

This section briefly summarizes the basic tenets and evolutionary story of the natural pedagogy theory. We then present the prima facie argument in support of the theory of natural pedagogy over some competing theories.

2.1 The basic tenets of the theory of natural pedagogy

The theory of natural pedagogy, as devised by developmental psychologists Gergely Csibra, György Gergely and their colleagues, takes children's learning to be a rather passive acquisition of general knowledge from observing behavior modeled by any individual who signals the beginning of a learning opportunity. The theory advocates the existence of a set of human unique and innate cognitive adaptations for the transfer of knowledge through active teaching. Concisely, they describe the theory as such:

> [Natural pedagogy] makes it possible to efficiently convey knowledge with opaque content to others in *a single act* of demonstration not only because the recipient is prepared to recognize such actions as communicative demonstrations, but also because

> the addressee has the default expectation that the content of the demonstration represents *shared* cultural knowledge and is *generalizable* along some *relevant* dimension to other objects, other occasions or other individuals (Csibra & Gergely, 2011, 1150, italics added).

There are a number of elements of natural pedagogy that emerge from this passage. First, the kind of knowledge acquired via natural pedagogy is *generalized* or *shared*, rather than idiosyncratic information. Elsewhere, Csibra, Gergely and their colleagues also write that natural pedagogy "assumes that ostensively communicated manifestations are more likely to convey semantic or generic information about the reference than episodic information that obtains only in the here-and-now" (Topál et al., 2008, 1832). Generalized knowledge can include the functions of objects, object kinds, as well as the society's social norms (see the details below). Second, children tend to understand that knowledge acquired via ostensive signals is *relevant* to the context. For example, infants may acquire different sorts of generalizable knowledge depending on whether they observe an adult reaching toward an object or pointing at the object (e.g., Yoon et al., 2008). Third, children acquire generalized and relevant knowledge not by statistical inference based on multiple experiences but from *only one* instance.

The theory of natural pedagogy argues that acquiring such generalized and relevant knowledge from only one instance is possible given the adult's *ostensive signals*, which include child directed speech, eye contact, use of child's name, eyebrow raising, and contingent reactivity (Csibra & Gergely, 2006, 262; Gergely, 2008, 174). Young infants are highly sensitive to such ostensive signals. For example, even 2-day-old infants are interested in directed gaze more than averted gaze (e.g., Farroni et al., 2002) and 6-months-old infants prefer to follow the gaze of ostensively signaling experimenters (Senju & Csibra, 2008). Moreover, since sensitivity to ostensive gestures occurs in very young infants, they think that natural pedagogy consists of a set of innate traits for learners.

Csibra, Gergely and their colleagues argue that natural pedagogy should function in a wide range of domains; children should take advantage of their evolutionary inheritance to learn about food items, cultural practices, tool construction and use, in addition to more contemporary skills such as computer use, crossing the street, or even

reading and writing (e.g., Csibra & Gergely, 2006; Király et al., 2013). However, almost all experimental evidence provided in favor of the theory of natural pedagogy has focused on domains of artefacts: kinds (Futo et al., 2010; Topál et al., 2008; Yoon et al., 2008), functions (Sage & Baldwin, 2011), and valence of objects (Gergely et al., 2007; Egyed et al., 2013). Nonetheless, they argue that natural pedagogy should function in other domains of human behaviors, including common practice, conventions, or traditions (Csibra & Gergely, 2006, 2011; Gergely, 2008; Király et al., 2013), words, religious superstitions, myths, rituals, and symbolic gestures (Gergely, 2008)[1]. In section 3.2, we examine these domains and argue that they are more limited than the theory has supposed.

2.2 The evolutionary story of the theory of natural pedagogy

In addition to their developmental story, Csibra and Gergely have developed an evolutionary story about the rise of natural pedagogy, according to which natural pedagogy precedes mindreading and language. For example, they argue as follows:

> …[W]e hypothesize that the "birth of pedagogy" was necessitated by extensive tool use by early hominid groups, and especially by the appearance of mediated tool use generated through 'recursive' teleology that decoupled means and ends in such a way that made these functional aspects opaque and uninferable for the uninformed observer. In fact, proliferation of tool use, and the emergence of rich artefact culture, would have probably been impossible without an efficient social learning mechanism that enabled transmission of not just observable behaviours but also unobservable knowledge (Csibra & Gergely, 2006, 256).

As tool functions and mechanisms become more complex, they should also become more opaque to novices. So unless some efficient social learning mechanism like natural pedagogy evolved, faithful replications of such highly complex cultural items and the cumulative evolution that can be found in human cultures would be impossible. They

[1] Moreover, the theory of natural pedagogy includes not only the learners' side but also the teachers' side, such that we should expect cognitive adaptations for teachers as well as learners (e.g., Gelman et al., 2012). However, since there is no clear empirical evidence that adults have the variety of cognitive adaptations predicted for teachers, our examination will focus on the learner's side of the natural pedagogy theory.

also argue that archaeological records support their evolutionary hypothesis: Making stone tools or tools made of perishable materials appeared at least 2.5 Myr ago, and because the techniques needed to make such tools are highly opaque to novice learners, natural pedagogy might have evolved as early as this period (Csibra & Gergely, 2011, 1155). We examine the plausibility of this evolutionary story in section 3.1 by referring to ethnographic data on hunter-gatherers.

Furthermore, while teaching is usually costly for teachers, and its evolution is often explained in terms of kin selection (e.g., Thornton & Raihani, 2008), Csibra and Gergely think that natural pedagogy is extended to communications among non-related people. As evidence for this claim, first, "[i]nfants smile to *any* adult who communicates to them, more probably follow a strangers' gaze than that of the mother…and preferentially target them when they need more information about the situation" (Csibra & Gergely, 2011, 1155, italics added). Importantly, Csibra and Gergely seem to be committed to the view that infants will learn from *anyone* who provides them with the proper ostensive signal. In section 3.3 we examine some experimental data to challenge this position.

2.3 Some proposed explanatory merits of the theory of natural pedagogy

Advocates of the theory of natural pedagogy have argued that the theory can explain some intriguing phenomena better than other theories. For instance, they argue that overimitation (i.e., imitation of the range of behaviors modeled, including the ones that are unnecessary for achieving the goal of the action) can be better explained in terms of the theory of natural pedagogy. As far as we know, overimitation was first reported in Meltzoff's well-known study, where 14 month-old children were engaged in a communicative session with an adult demonstrator who showed the child that she could turn on a light box by touching it with her head. A week later when the children were permitted to play with the light box, they more often touched it with their heads to turn it on, even though they had only seen the adult demonstrate the behavior once before, and, at least from the perspective of the psychologists, it is more rational for the children to turn on the box by touching it with their hands (Meltzoff, 1988).

A general explanation for children's overimitation is that it permits children to learn new and interesting causal relations in their world, and there are at least three

different theories about how it works. First, Andrew Meltzoff suggests that human infants have a drive to imitate human models, and that it is through imitation that children come to realize that others are "just-like-them" (e.g., Meltzoff, 1996). However, it has been pointed out that an innate disposition like this doesn't explain why children sometimes *do not* overimitate (Gergely & Csibra, 2005).

Second, Michael Tomasello's account of overimitation does address the selective nature of the phenomenon, but it seems to make the wrong predictions about when children should overimitate. As on Meltzoff's account, Tomasello thinks that the infant identifies with the model, but unlike Meltzoff, Tomasello thinks that true imitation requires knowing the goal of the action, and the actor's intentions, and that children have an innate drive to want to share goals with others. The desire to share actions with others leads children to imitate cognitively transparent behavior (Tomasello, 1999). On this account, children should overimitate when they understand the action, but not in cognitively opaque situations, an example of which Gergely & Csibra take to be Meltzoff's lightbox (Gergely & Csibra, 2005). Thus, Tomasello's account seems to make the wrong predictions, if we take the children's behavior to be imitative.

Finally, the natural pedagogy explanation of Meltzoff's finding of overimitation begins with the claim that his study is:

> a textbook example of pedagogical learning: the teacher (the model) (1) established a teaching context by an ostensive stimulus (eye contact), (2) identified the reference object (the magic box) by looking at it and touching it, and (3) demonstrated a novel action (touching the box with her forehead) that created a novel effect (lighting up the box). In response, infants learned in a single trial both the function of the novel object and the special way it should be operated, and retained this knowledge for a relatively long time (Csibra & Gergely, 2006, 11-12).

In contrast to the other hypotheses, Csibra and Gergely claim that children are predisposed to imitate novel actions that are cognitively opaque, in a pedagogical setting. Overimitation in such contexts allows children to learn a new behavior without initially understanding the goals or the causal interactions needed for achieving the goal. And,

overimitation permits faithful transmission of important technological behavior from generation to generation.

Gergely and Csibra offer two pieces of evidence for their pedagogical explanation of overimitation: when children have a rationalization for the odd action, they do not overimitate (Gergely et al., 2002), and when there is no ostensive gestures, children do not tend to overimitate (Kiraly et al., 2004). The first piece of evidence comes from a variation of Meltzoff's study in which the adults were using their hands to hold a blanket, rendering them unusable for another task. The infants tended not to imitate the adults in this condition, using their hands to turn on the light instead. Gergely and colleagues interpret this finding as evidence that children will rationally imitate; when children understand an action, they will not take the ostensive signal to indicate a teaching situation. That is, in communicative situations children will overimitate when the situation is opaque, but not when it is transparent. Thus, while it appears that the theory of natural pedagogy can explain overimitation well, in section 4.1 we examine a range of overimitation experiments and argue that overimitation cannot be explained fully in terms of the theory of natural pedagogy, either.

Finally, the theory of natural pedagogy takes children to be open to pedagogical learning before they develop mindreading skills or even full-fledged linguistic capacities. The innate responsiveness to pedagogy and ostensive cues helps to resolve the puzzle about children's mindreading capacities, namely, why very young infants appear to pass nonverbal false belief tasks (e.g. Onishi & Baillargeon, 2005) and yet they fail verbal versions until about 4 years old (Wellman et al., 2001). The theory of natural pedagogy explains how infants are sensitive to the existence of communicative intentions in others without being able to grasp the content of those intentions (Csibra, 2010). A host of data suggests that infants are sensitive to pedagogical contexts before 14 months, long before mindreading capacities allow children to consider the content of another's false belief (Csibra & Gergely, 2006, 2009, 2011).

2.4 Summary

Natural pedagogy allows novice learners to gain generalizable or shared and relevant knowledge more efficiently and frequently, especially in opaque contexts, across different domains from a single demonstration by any adults with ostensive signals.

Natural pedagogy is independent from, and probably evolved before, full-fledged mindreading and language capacities, and purports to explain some intriguing phenomena such as overimitation better than other theories.

3. Some initial worries about the theory of natural pedagogy

In this section we present some worries about three aspects of the theory of natural pedagogy: the evolutionary story, the domain generality of acquired knowledge, and children's promiscuous acceptance of teachers. First, on the evolutionary story, it seems that faithfully learning how to make and use complex tools would be possible without the evolution of natural pedagogy, since some children in hunter gather societies learn many things efficiently, such as social traditions, even without active teaching or modeling with ostensive cues. Second, although children are supposed to learn a wide range of information types through natural pedagogy, it may be that the domain of knowledge that is acquired through natural pedagogy mechanism are limited to learning generalizable knowledge about objects. Third, while Gergely and Csibra suggest that any benevolent demonstrator can facilitate children's learning by using ostensive signals, there is evidence that children preferentially learn from prestigious individuals.

3.1 Evolution of cumulative culture

The theory of natural pedagogy explains the cumulative evolution of complex tools by the adaptation of natural pedagogy; the "proliferation of tool use, and the emergence of rich artefact culture, would have probably been *impossible without* an efficient social learning mechanism" (Csibra & Gergely, 2006, 256, italics added) like natural pedagogy. While natural pedagogy is one possible social learning mechanism, facilitative teaching is another. Facilitative teaching involves giving the learner some opportunities for learning without giving explicit instructions, and it is widespread in human (and animal) cultures as a means for learning the complex techniques needed for practices such as hunting and tool construction. While there is little evidence for explicit teaching (i.e., teaching with ostensive communications or demonstrations) in hunter-gatherer societies (e.g., Csibra & Gergely, 2009), there is a large body of ethnographic evidence showing how important facilitative teaching is for these societies today (e.g., Boch, 2005; MacDonald, 2007; Marlowe, 2005, 2007). For example, in a thorough survey on ethnographic studies on

learning in hunter-gatherer societies, MacDonald (2007) concludes that "[t]he sources discussed here suggest that a range of learning processes are involved in acquiring hunting skills, and that teaching and demonstration play a limited role" (398). Rather, her survey shows that in hunter-gatherer societies, facilitative teaching such as allowing novices to accompany experts on hunting trips and allowing novices to play with a tool or its toy model is more common.

The importance of facilitative teaching has recently been developed by Kim Sterelny (2012) in his *apprentice learning model*. The model points out the possibility that humans have evolved in a richly organized environment for learning, and even without explicit teaching, and without any specific cognitive adaptations for social learning and teaching, humans may accumulate complex cultures. First, like other non-human animals such as meerkats, whose young gradually learn how to kill and eat dangerous scorpions from adults by first provisioning dead scorpions and then half-killed scorpions, human experts often prepare gradual learning steps for apprentices by "task decomposition" and "ordering skill acquisition" (Sterelny, 2012, 35). Second, in such an organized environment, children are given many opportunities for learning by adults. As MacDonald (2007) also points out, in traditional societies, adults are often very tolerant of children looking at their activity closely, participating in adults' conversation, and playing with their tools, which should be good learning opportunities for children. Thus "while the role of explicit teaching in traditional societies is often quite limited[2], adults can and do structure and engineer the learning environment, even without explicit teaching" (Sterelny 2012, 36)[3]. It is the adults' sensitivity to the child's level of capacity that allows children to learn to build and use complex tools and gain other types of cultural knowledge efficiently and faithfully.

Therefore, if Sterelny's model, MacDonald's survey, and other ethnographic studies are correct, one cannot infer directly from the existence of some complex technique appearing in a society that children must learn it from explicit teaching; facilitative

[2] Only one exception is Hewlett et al. (2011)'s report showing that !Kung children depend largely on explicit teaching. However, if Csibra and Gergely's evolutionary story is right, we should expect to find explicit teaching in many different cultures. This one exception is insufficient for supporting their claim.
[3] Note that Sterelny himself thinks his model is consistent with the theory of natural pedagogy. However, his argument challenges Csibra and Geregly's evolutionary story for the theory of natural pedagogy by showing that the evolution of complex cultures does not necessarily need the evolution of teaching with ostensive communications.

teaching or apprentice learning may be sufficient; explicit teaching using ostensive communications is not necessary for faithful transmission of complex techniques. Thus it is possible that the need for complex tool learning didn't serve as a strong selective pressure for cognitive adaptations related to teaching.

3.2 Domains of generalizable knowledge

The second worry has to do with the kinds of knowledge children can gain from adults' ostensive signals. There is empirical evidence that ostensive signals do not facilitate children's learning of generalizable knowledge in at least some domains, which suggests that the domains for natural pedagogy may be fewer than thought. For example, normative rules are learned just as efficiently without ostensive cues (Schmidt et al. 2010). Schmidt and colleagues show 3-years-old children an experimenter manipulating an object in two different situations: In the 'recognizing' situation, the adult behaves as if she already knows how to manipulate the object, while in the 'inventing' situation, she behaves as if it is the first time manipulating it. Furthermore, each situation is divided into two further situations: experimenters use ostensive cues (the 'ostensive communication' situation) or pretend to be indifferent to children (the 'incidental observation' situation). Thus there are four situations, (1) recognizing-ostensive, (2) recognizing-incidental, (3) inventing-ostensive, (4) inventing-incidental ones. Next, the experimenter gives the object to the children without normative language or any instructions and the children can imitate the experimenters' behaviors as they choose. Finally, a puppet, called Max, comes in the room and manipulates the object differently from the experimenter. After the children see Max's behavior, researchers note whether children object to Max's behavior. When children protest that Max is not using the object properly, they are indicating that there exists a norm for the object, and that this norm is generalizable, and so it is applicable to Max.

If ostensive cues allow infants to learn knowledge about general norms more efficiently, then we would expect a significant difference between the ostensive conditions (1)-(3) and incidental (2)-(4) situations. However, the results clearly show a significant difference between (1)-(2)—the 'recognizing' conditions—and (3)-(4)–the 'inventing' conditions, which suggests that ostensive signals do not permit children to learn generalizable norms more efficiently. As the authors suggest, this may be because

experimenters in the 'recognizing' situation look like reliable resources for children, so they can learn norms at a significantly higher rate than in the 'inventing' situation.

This experiment shows that children can learn generalizable norms from a single observation, and the addition of ostensive cues does not facilitate this norm learning. Children may be particularly sensitive to norms, given their importance in human communities, and those children who are able to automatically pick up on norms may be at a greater advantage than those who need a willing teacher to demonstrate them.

3.3 Selective learning and model types

Finally, though the theory of natural pedagogy seems to be committed to the view that children will learn from anyone who provides them with the proper ostensive signal[4], the epistemic trust literature suggests that children are quite choosy about whom they learn from. For example, according to one form of model bias, prestige bias, learners preferentially learn from prestigious individuals, defined as those who get more attention from bystanders (Henrich & Gil-White, 2001). Recent research provides evidence of prestige bias in children, and suggests that ostensive signals do not facilitate children's ability to determine whether an individual is prestigious.

In Chudek et al. (2012), authors found that 3- and 4-year old children will preferentially learn about artifacts from a prestigious person, that is, a person "to whom other learners have preferentially attended or deferred" (47). In Study 2, children first watch a clip in which bystanders pay attention to the one model (the prestige model) and not to the other in either an artefact or food condition. Importantly, while both models show ostensive signals to the camera (i.e. to the subjects), the bystanders from whom the children are learning the model's prestige status do not give any ostensive signals; they do not directly talk to or look at the subject, but simply watch the model. Next, the

[4] For instance, as we have already mentioned, they said "[i]nfants smile to *any* adult who communicates to them" not just their parents (Csibra & Gergely, 2011, 1155, italics added). They claim too that children can "learn generic kind-relevant information directly…from benevolent communicators who manifest generic knowledge 'for' them that would be difficult (if not impossible) to acquire without such support." (Csibra & Gergely, 2009, 152). These are just two examples of the many instances in which Csibra and Gergely suggest that natural pedagogy allows children to gain generalizable knowledge from any adult who ostensively communicates with them.

subjects see the two models manipulate the same novel artefact by using different tools, or eating or drinking two different novel foods or beverages. Finally, when the children are asked to choose which models' behavior to imitate, around 70% of the subjects choose the prestigious model, *but only if the imitation opportunity is in the same domain in which the prestige cue is shown*. This indicates that there is a clear and strong prestige-bias effect on children's learning in the same domain as the prestige cueing situation.

While the theory of natural pedagogy suggests that learning (and imitation) is facilitated by ostensive signals given by a benevolent demonstrator, this study shows that isn't true; when confronted with conflicting information from two equally benevolent communicative partners, children of 3 and 4 years will already be able to evaluate the quality of the information, and choose who to imitate by considering relevant evidence. This suggests a more intellectually active role for children than described by natural pedagogy. As the authors of this study argue, the experiment suggests that in an opaque context where novel artefacts and foods are shown and it is unclear who is trustworthy, the children must infer two kinds of information: who is trustworthy in the domain, and which behavior they should imitate. Moreover, note that a considerable percentage (70%) of the subjects can choose the prestigious model even when bystanders do not give any ostensive cues to the subjects. Although it is possible that more subjects would imitate the model if bystanders gave ostensive cues, even so, its effect must be limited given the effectiveness of prestige bias. Thus ostensive signals may not always be efficient for learning who is trustworthy or not, and for coming to learn skills demonstrated by a trustworthy model.

One might argue that the children in these experiments as well as the children presented in ethnographic evidence such as MacDonald (2007) are much older than the subjects in almost all the experiments done by Csibra, Gergely and their colleagues (e.g., Futo et al., 2010; Gergely et al., 2007; Topál et al., 2008; Yoon et al., 2008). However, Buttleman et al. (2013) suggests that even 14-months-old infants are choosy about whom they learn from. In this experiment, the experimenter shows infants that she turns on a light box by touching it with her head. What is important is that when she does so, she gives ostensive signals and speaks in either a native or a foreign language to the infants. The theory of natural pedagogy might expect that infants would imitate the head-touching behavior regardless of which language the model speaks, because in both cases the model

engages the child using ostensive gestures. However, the results show that infants imitate the behaviors by the experimenter speaking the native language at a significantly higher rate than the behavior demonstrated by the foreign language speaker. So this suggests that even 14-months-old infants actively choose which models to imitate. While Csibra and Gergely suggest that children imitate any benevolent model who ostensively signals a learning opportunity, there doesn't seem to be anything riding on that commitment. If the children already have to distinguish between benevolent and malevolent demonstrators, children are already engaged in a more active analysis of what makes a good model. Distinguishing between other features, such as in-group members vs. out-group members, could be another ingredient in a more active learning process in children. It seems that the theory of natural pedagogy would not be harmed were they to drop the commitment to the view that children learn from anyone who provides ostensive cues, but that ostensive cues, along with other signals given off by the potential model are together taken into account when a child decides whether to imitate the model.

2.4 Summary

Much ethnographic evidence points out that learning to make and use complex tools does not require explicit teaching. Some experiments suggest that neither explicit teaching nor ostensive signals are more efficient for learning social norms and people's trustworthiness. Finally, children prefer to learn from prestigious in-group models. Taken together, this evidence suggests that children are more cognitively engaged in their learning than one might expect given the three commitments of natural pedagogy discussed above. Children are choosy about who they learn from, and the theory of natural pedagogy downplays this aspect of human learning. Children prefer to imitate prestigious in-group models, sometimes without any active teaching or ostensive signaling. This makes sense given that children must learn their own cultural practices and beliefs, and this is better done by adopting those of prestigious in-group members rather than by mimicking others indiscriminately.

These three points suggest that while there may be innate mechanisms that drive children to learn from demonstrators who signal learning opportunities, special natural pedagogy adaptations need not have played a role in the evolution of culture because there are alternate means for gaining cultural knowledge. As well, while it may be that

children learn generalizable facts from active teaching in some domains, it may not be that the mechanisms are needed for learning generalizable knowledge in *all* domains. Finally, the suggestion that children can learn from anyone may be tempered as well, and the theory can be supplemented with accounts from the epistemic trust literature. Further work is required to show how natural pedagogy mechanisms interact with mechanisms that allow children to select appropriate models. While a tempered version of the theory of natural pedagogy may be true, it is at best an incomplete account of children's learning. In the next section we put further tension on the theory by arguing that the evidence presented in favor of the theory is better explained in other terms.

4. Alternative interpretations of the empirical evidence presented in favor of the theory of natural pedagogy

Advocates of the theory of natural pedagogy defend the theory with a number of experimental results on children's learning. Given the number of different experiments that seem to demonstrate that children gain different kind of information when in an ostensive communicative situation as compared to a non-communicative situation, there is a strong prima facie case for the view that infants expect to be taught about the world when adults communicate to infants using ostensive gestures. However, given the existence of alternative explanations for these findings, the case for the theory of natural pedagogy is weakened.

4.1 Overimitation

Overimitation is one of the most important phenomena for the theory of natural pedagogy; advocates of the theory have argued that the theory of natural pedagogy can better explain overimitation than other theories. Here we examine that position by examining additional studies on overimitation that are less compatible with the account.

4.1.1 Rationalization and failures of overimitation

According to the theory of natural pedagogy, children tend to overimitate in opaque contexts, but not in transparent ones. When an adult uses her hands to hold a blanket around her cold body, and then uses her head to turn on a light box, children use their hands to turn on the light (Gergely et al., 2002). Gergely and colleagues interpret this

finding as evidence that children only rationally imitate; when children understand an action, they will not take the ostensive signal to indicate a teaching situation. As they put it, in communicative situations children will overimitate when the situation is opaque, but not when it is transparent.

However, other studies of overimitation are harder to interpret in terms of rational imitation. Pinkham and Jaswal (2011) find that eighteen month-old children fail to overimitate in what appears to be an opaque context. In the "Self-Discovery" condition of their experiment, before an experimenter demonstrates, children were allowed to play with the light box and learned on their own how to illuminate it with their hands. After learning how to operate the light box themselves, children fail to overimitate an experimenter who demonstrates turning it on with her head even with ostensive signals. This situation is opaque in the sense that the child plausibly did not understand why the experimenter touched the light box with her head.

The defenders of natural pedagogy might respond that infants do not overimitate because this situation is transparent for the infants in the sense that they have already known how to manipulate the light box. Indeed, Király et al. (2013, 483) argue that Pinkham and Jaswal (2011)'s experiment is consistent with their theory because "when children have already acquired means–end knowledge about an artifact (which, therefore, is no longer novel), they do not learn a nonefficient means action performed on it even in an ostensive communicative context".

However, there is also evidence that older children overimitate and learn inefficient means to perform an action in transparent situations. For example, in Lyons et al. (2007)'s experiment, first, the experimenter instructed the 3- to 5- years-old children not to imitate "silly" and irrelevant behaviors and to focus on the actions that the adult "had to do". In this situation, the silly and irrelevant behavior is touching a bottle with a feather before opening the bottle. Next, the experimenter showed the children how to open a new transparent box in both relevant and "silly" irrelevant ways (e.g., pulling out the red bolt inserted in the top of the box, which is completely irrelevant for opening the box) while again instructing the children not to imitate silly behaviors. Despite repeated instructions, after the experimenter left the room, the children overimitated the silly steps. Since the box is transparent and the causally relevant steps are clear for the children, this

is a transparent task so the results suggest that overimitation also occurs in transparent contexts.

Another problem with replying to Pinkham and Jaswal's (2011) failure to find overimitation by suggesting that the task is transparent is that the theory of natural pedagogy's evolutionary story is supposed to explain high-fidelity transmission of behaviors across generations. Just because the child discovered one way of opening the box doesn't mean that it is the correct way to open the box. High-fidelity transmission involves copying the way a task is performed, and requires understanding that an action should be done in a particular even if there are other, simpler, ways of achieving the goal. For the development of cumulative culture, creating the tools in the right way is essential, for the next step may build on what appears to the child to be an irrelevant feature of the artifact.

Insofar as the theory of natural pedagogy is meant to be an account of how children learn norms, it would be important to overimitate behavior even after the child knows how the object works. Ritual and ceremony involve special ways of moving, handling objects, and so forth that a child has to learn in order to be accepted as a full member of that society. For example, a child may discover that using her sleeve is an efficient way to clean her mouth, but over time can imitate adult behavior and learn to use a napkin instead. There are various lenses through which one can see an action, and while a child may fully comprehend the causal relationship between the action and the outcome, she may also need to learn the ritual, superstition, and cultural norms associated with the outcome. If natural pedagogy is used to learn social norms, children should change their behaviors to imitate adult models even if they have already discovered a different, and simpler, way to achieve a goal—that is, even if the situation is causally transparent.

Rather than accepting that knowing the causal structure of the object makes the task transparent, the defenders of natural pedagogy might argue that the behaviors may still look opaque, precisely because the behaviors are "less efficient" for solving the puzzle. Indeed, according to Gergely (2008), "less efficient" actions are teleologically opaque, and actions that are "clearly justifiable" are transparent.

However, then they have to conclude, additionally, that the experimenters' behaviors in Pinkham and Jaswal (2011) are also opaque for the children. In this

experiment, as we have explained before, eighteen-months-old children learned how to turn on the light box through free play, but then failed to overimitate the experimenters' irrelevant actions (i.e., touching the light box with their heads) even when the experimenters showed such irrelevant actions with ostensive signals. The experimenters' behaviors here would be opaque to the children because after the children learned how to turn on the box, the children would understand that touching the light box with their heads is not "clearly justifiable," and is "less efficient" than touching with hands. But, because the children fail to overimitate in this context, advocates of the theory of natural pedagogy cannot make this move. Thus this reply is not available to defenders of the theory of natural pedagogy since it cannot explain the fact that the children do *not* overimitate in such an opaque context.

While the hypothesis that children primarily overimitate in opaque contexts may seem like an empirically tractable prediction, there is the question of how we can verify whether a situation is opaque or transparent to the child. Of course, even if the causal relations are obvious to the adults, it doesn't follow that they are obvious to the child. How does one determine which contexts are transparent and which are opaque? Gergely's (2008) distinction between opaque (i.e., "less efficient") and transparent (i.e., "clearly justifiable") actions doesn't help solve the question, because we need to know whether the action is deemed "less efficient" or "clearly justifiable" by the child.

One way to determine whether or not a situation is opaque or not to an individual may be to let the subject enter into the situation in a non-pedagogical setting, and see if she can solve the problem. Interestingly, children are largely able to solve the sorts of problems at issue in a free exploration setting more efficiently than when imitating (Meltzoff, 1988; Gergely et al., 2002; Lyons et al., 2007). For instance, in the Lyons et al. (2007) study, before experimenters demonstrate, children who were allowed to freely explore the puzzle box managed to open it without learning any irrelevant actions. Thus the authors conclude that the puzzle box is a transparent puzzle for the children. If that were true, the theory of natural pedagogy would predict that there should be no overimitation on such studies.

4.1.2 Alternative explanation of the overimitation data: The information-seeking account

It seems that the data taken as a whole suggests not that children are just overimitating in order to learn about objects in the world, and are ready to be taught by willing adult models who simply serve to signal what should be learned. Rather, it may be that while there are different explanations for each of these cases, the overall data suggest children are actively engaged in seeking to understand their world, including both the objects in their environment and the actions they observe people perform (e.g., Andrews, 2012). Explanation-seeking is likely a universal drive found in early stage of human development, and one that has been acknowledged by philosophers from Plato's *Meno*, to Hobbes's "lust of the mind" (1651/2011), and Hume's painful curiosity that "chiefly takes place, where interest, relation, or the greatness and novelty of any event interests us" (1739-40/1978, 453). For instance, data from North American subjects show that children engage in explanatory practices as 2-year-olds (Hood & Bloom, 1979) or even earlier (Chouinard, 2007). Chouinard (2007, especially 22-24) analyzes a corpus of questions asked in natural settings on four one- to five-years-old children. She finds that children ask 107 questions per hour on average, of which 71% are information-seeking questions such as "What's that?" and "What is he doing?" Importantly, the frequency of the information-seeking questions is significantly higher than noninformation-seeking questions like "Can I go outside?" (permission question) or "Hey mom?" (attention-getting question), which is not limited to older children but found even in one-year-old children.

This active engagement appears to be sensitive to a number of variables. In some cases, children overimitate because they do not yet know how to use a demonstrated object; in other cases, they overimitate because they do not know how the object works—its causal structure—or they do not know what it is for—its functional role. We would expect that in the latter situation children are motivated to learn the norms of their community. Actually, as Buttleman et al. (2013), Schmidt et al. (2010), Keupp et al. (2013), and others suggest, children may have an innate desire to understand and follow social norms, and so they tend to overimitate the strange behaviors performed by in-group members (such as those speaking one's native tongue) as opposed to out-group members. Even without ostensive signals, children tend to learn novel behaviors as generalizable social norms from trustworthy models. In other cases, they overimitate to explain unnecessary and strange behaviors even if they already know the causal structure

of the object, or have already manipulated it and understand its affordances, as shown by Lyons et al. (2007, 2011).

Furthermore, Poulin-Dubois et al. (2011) shows that thirteen- to sixteen-month-old infants fail to overimitate an adult turning on the light box with her head if they have evidence that she is unreliable. In this experiment, infants observe an experimenter look into a box using ostensive signals. The experimenter exclaims, "Wow!", raises eyebrows and smiles at the child, as if indicating there is an object in the box. In the reliable situation, there is actually a toy hidden in the box while in the unreliable situation, the box is empty. Next, the infants are given the box to look inside, and come to learn whether the adult is reliable or not i.e., whether the adult correctly indicates whether there is a toy inside. After this warm-up phase, the infants are cued with child-directed speech and then shown the adults' demonstrations, and asked to imitate the adults' behaviors. Despite the ostensive signals, the infants do not overimitate the unreliable adult's behavior. This is consistent with our information-seeking account because children do not need to explain the behavior of unreliable models; they should only be interested in the behaviors of reliable models. Unreliable models neither offer information about themselves in terms of their reasons for action, nor do they provide generalizable knowledge about objects. They are also useless for children who want to learn about societal practices. Reliable models are able to offer all this, as well as information about other domains of knowledge, such as the social norms that may not appear rational from a purely causal perspective. Therefore, as the vast literature on epistemic trust suggests (e.g., Harris & Corriveau, 2011; Koenig & Harris, 2005; Poulin-Dubois et al., 2011; Sternberg, 2011), there is a dynamic interaction between learning generalizable knowledge about objects and learning about people, and given the range of responses we see in overimitation, each of these cases is plausibly explained in terms of the child's more general interest in explaining her world.

4.2 Function of Ostensive Cues

In response to our claim that human infants are learning about people, norms, and objects in a dynamically coupled way, supporters of natural pedagogy will point to data suggesting that ostensive cues have an effect on *what* children learn, as well as offering a signal that a learning opportunity is at hand. Gergely, Csibra and their colleagues provide

empirical evidence that ostensive cues lead children to learn generalizable knowledge about objects, rather than offering any information about people or norms. In this section, we will challenge that claim; we think that a careful review of the studies cited in favor of the claim shows that none of them offers compelling support. Instead, we show how the findings can be explained in terms of familiar social psychological mechanisms, suggesting that further evidence is needed to decide between these explanations.[5]

4.2.1 Valence of objects

Perhaps the strongest set of developmental evidence offered in favor of the role of ostensive cues is the finding that 14-month old infants use an actor's behavior to draw conclusions about objects in the world when the object-directed behavior is accompanied by ostensive signals, and to draw conclusions about the actor when the behavior is not accompanied by ostensive signals (Gergely et al., 2007). In this study, infants are given one of two sets of familiarization trials where two adult models first display ostensive cues toward the infant and then consistently express either positive or negative attitudes toward two different objects, such that the models have opposite attitudes toward the objects. In the symmetric familiarization condition, the two models appear with the same frequency, such that the infants see the same attitude expressed to each object the same number of times. In the asymmetric familiarization condition, one of the two models appears three times more often than the other, and her attitudes are more frequent. After familiarization, the infants are shown the models engage in either attitude-consistent or attitude-inconsistent actions. The authors expect that if the infants are mindreading, they should show surprise when presented with attitude-inconsistent actions, regardless of familiarization condition. However, if infants are learning generalized knowledge about the valence of the object rather than specific knowledge about the person's preferences, those in the asymmetric condition should be surprised when either model chooses the object that was more frequently associated with a negative attitude. While the mindreading prediction was not born out, the object valence prediction was, which the

[5] For the sake of space, the paper does not refer to some experiments on function of ostensive cues, especially on identity of objects (Yoon et al. 2008) and A-not-B errors (Topál et al 2008) though it seems that both have some problems. For instance, Yoon et al. (2008) does not seem to distinguish between identifying an object over time and as a member of a kind, and Vorms (2012) has also pointed out some problems with Topál et al (2008).

authors interpret as evidence that children have an object-centered rather than a person-centered interpretation of demonstrations in an ostensive signally situation.

Similar results are also reported by Egyed et al. (2013). They found that 18 month-olds who observe an experimenter show different emotional reactions to two objects generalize these emotions to another person when they are first demonstrated in a communicative setting, but not when demonstrated in a non-communicative setting. That is, when infants observe a person showing disgust toward an object while interacting with the child, they more often come to expect that other people do not prefer that object either. However, if the experimenter fails to engage the infant via eye contact or speech, they are less likely to generalize; rather, they act as if the display is the personal preference of the experimenter, and they often offer the disliked object to another individual.

4.2.2 Alternative explanation of the object valance studies: Social-reference and epistemic-trust account

While these studies are suggestive, there are alternative explanations for their findings consistent with well-established theory. First, one could offer the following alternative account to Gergely et al. (2007)'s study. The social referencing literature suggests that by one year infants use others' expressions to guide their own behavior toward a new object or situation (Walden & Ogan, 1988, Klinnert, 1984), and infants adopt others' emotional states toward individuals even without ostensive cues; this is called the "indirect effect" (Feiring et al., 1984). In Feiring et al. (1984), 15 month-old infants played as their mother interacted in a friendly way with a stranger, or ignored the stranger. When the stranger tried to engage the infant in play, those children whose mothers interacted with the stranger were less wary of the stranger. Thus, the infants in Gergely et al. (2007)'s study could have come to adopt the most frequently displayed emotional response to the object, and then, based on the egocentric orientation of children under 2 years-old (e.g., Repacholi & Gopnik, 1997), they would predict that others have the same emotional preferences as they themselves do. Given this interpretation, the infant's behavior in this study isn't best understood in either person-centered or object-centered terms; rather, the behavior indicates that there is problem with the distinction. Indeed, as we've already suggested, we think that it is more plausible that children come to learn about people and objects in an intimately interconnected way.

Next, while Egyed and colleagues think this study offers support for the claim that infants learn generalized knowledge about objects in communicative situations, but not knowledge about persons or norms, there is also a possible alternative account for this study. Consider the power of the averted gaze; studies suggest that averted eye gaze is sufficient to "signal low relational evaluation" and bring about a feeling of "social exclusion" (e.g., Wirth et al., 2010, 870) to the perceivers. In Wirth et al. (2010), 26 undergraduates watch eight movies in which actors direct eyes toward or avert their gazes from the students. Subjects report that they felt significantly more excluded and less self-esteem after watching averted-gaze movies than directed-gaze movies. This means that someone averting her eye gaze from us is likely to make us feel that we do not belong to the same group, which in turn causes us to distrust the person. If such a reaction is present in infants, this can easily explain the results of Egyed et al.'s study: When the experimenter averts her gaze and the requester shows explicit eye contact to infants, the infants deem the experimenter as not being a member of their group and take the experimenter to be less trustworthy than the requester; they do not regard the experimenter's evaluation as important. Thus we can explain the results of Egyed and colleagues without appealing to the theory of natural pedagogy.

4.3 Summary

While a variety of studies provide empirical support for the theory of natural pedagogy, the evidence is also compatible with a different account of how children learn. In particular, appeal to findings from the epistemic-trust literature may explain the empirical data better than the theory of natural pedagogy.

One might respond to the above arguments that the theory of natural pedagogy may be incorporated into the epistemic trust findings; for example, perhaps ostensive signals are limited to those signals that also serve as indicators of trustworthiness, or perhaps general ostensive signals must be coupled with additional signals of trustworthiness for the child to learn from the model. Although this possibility cannot be denied, it should be noted that if advocates of the theory of natural pedagogy accept it, the theory is more limited than the advocates have assumed. If ostensive signals are not automatic triggers, but instead require interpretation on the part of the child, there need not be any cognitive adaptations specific for teaching to explain children's sensitivity to

trustworthy signals. Rather children would be developing general purpose strategies for deciding who to trust that serve a variety of functions—seeking safety, love, and affection, as well as knowledge. Once a child trusts someone, that person can offer more than just a learning opportunity.

5. Conclusion

Contrary to the view advocated by defenders of the theory of natural pedagogy, infants and young children actively engage in their education, seeking out learning opportunities from the right kind of humans, via observation of demonstrations as well as incidental behaviors. The theory of natural pedagogy predicts that children should learn from anyone, indiscriminately, but they do not. The theory of natural pedagogy predicts that they should not actively seek out models, but they do. And while the theory of natural pedagogy insists that learning requires ostensive cues, children are quite capable of learning without them. The reason why the theory of natural pedagogy fails to explain the data is that it does not take into account that children learn about physical objects and people *at the same time* and in ways that are not separable or distinguishable; looking at how children learn about the physical world in isolation from the way they learn about the social world is a mistake.

While the theory of natural pedagogy is one popular account used to explain why children are interested in imitating irrelevant behaviors, it seems that the data currently on the table do not support the theory of natural pedagogy as presented by Csibra and Gergely. Rather, the findings that children are particular about when they overimitate supports an account of overimitation that must be spelled out by appealing to normative terms, and can be generalized to an account of children's learning about the world as being shaped by a general, yet primitive, sense of normative factors. As the literature on epistemic trust suggests, we suspect there is a dynamic interaction between children learning about the rule of the world as well as about people.

In some cases, children overimitate because they do not yet know how to use a demonstrated object, either because they do not know how to operate it—its causal structure—or they do not know what it is for—its normative role. Thus, it may be expected that in situations in which children are motivated to learn the norms of their community, they will overimitate even if they already know the causal structure of the

object, or have already manipulated it and understand its affordances. In this case, the reenactment of the unnecessary behaviors amounts to trying to understand why the agent acted as she did, and may serve as an entry into developing mindreading abilities (Andrews, 2012).

This early normative sense leads children to seek explanations for behaviors as well as causal structures that violate their expectations about the world. The question of where the origin of the human drive to explain remains unanswered, but given the existence of the drive, we have in place a motivation for learning. Early teaching may not be best understood in a framework in which with adults *decide* to teach; rather, early teaching may be one natural response to their children's lust for understanding.

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