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# Young children are natural pedagogues

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ABSTRACT

Young children are sensitive to ostensive cues (OC), a specific set of communication signals which denote a learning context. This endows human communication with a protocol – termed *natural pedagogy* – adapted to transmit knowledge. It remains unknown whether children spontaneously communicate in this protocol. Here, we show that children display a broad repertoire of ostensive signals during pedagogically relevant moments of their discourse. We introduce an experimental setup where an adult actor plays erroneously a simple inference game which the child has previously learned how to play. This naturally shifts the child from a student to a teacher's role in the educational dialog. In Study 1 ($n = 31$), we examine children's use of ostensive cues and gestures as they develop their explanations (3–5 and 6–8-years old). We demonstrate that all children use non-verbal behaviors specifically during moments of pedagogical relevance and the dynamics' use of ostensive signals change through childhood. In Study 2 ($n = 16$),

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the adult pupil minimizes all reception to non-linguistic OC and gestures. This resulted in a decrease of children's frequency of OC during pedagogical episodes but did not affect other gesturing behavior. In Study 3 ($n = 15$) we show that decreasing ostension during children's history of instruction does not decrease their own ostension while teaching. This rejects the hypothesis that children teach by simple imitation of their learning experience and showed instead, that they can diagnose the sources of the adult pupil's failure and adjust their own teaching accordingly. Together, these results demonstrate that children are spontaneously tuned in the emitter side of natural pedagogy.



## 1. Introduction

Teaching by definition involves two parties, a teacher and a pupil, who modify their behaviors in order to achieve a meaningful transmission of knowledge. This interaction constitutes the minimal core of pedagogy. While neuroscience and cognitive neuroscience have led to a thorough understanding of how we learn, we remain quite ignorant on the cognitive mechanisms of how we teach (Caro & Hauser, 1992; Davis-Unger & Carlson, 2008a, 2008b; Strauss & Ziv, 2012; Strauss, 2005; Thornton & Raihani, 2008). Paradoxically, teaching constitutes the most prominent and distinctive vehicle to propagate knowledge in human societies (Csibra & Gergely, 2011; Tomasello & Rakoczy, 2003), and has had a major impact on cementing our culture (Csibra & Gergely, 2011; Posner & Rothbart, 1998; Tomasello, Carpenter, Call, Behne, & Moll, 2005; Tomasello & Rakoczy, 2003).

Only recently have we begun to understand how teaching develops through life. A handful of studies showed that children spontaneously teach when they sense a disparity of knowledge (Maynard, 2002; Strauss & Ziv, 2012; Ziv & Frye, 2004; Ziv, Solomon, & Frye, 2008). It has also been shown that the exchange of knowledge between children is initially marked by guidance, with the child teacher regulating the experience and later on becoming a more collaborative behavior (LeBlanc & Bearison, 2004). How and when children engage in teaching was studied in the remarkable seminal work of Strauss and collaborators (Strauss & Ziv, 2012; Ziv & Frye, 2004; Ziv et al., 2008). The authors showed that children as young as age 3 teach effortlessly and spontaneously. In these first manifestations of teaching children rely mainly on demonstrative strategies. Five year old children accompany demonstrations with more elaborate explanations, including feedback behaviors and errors diagnosis (Strauss, Ziv, & Stein, 2002). Accordingly, Strauss and others proposed that teaching is a natural cognitive ability (TNCA) acquired at an early age without any apparent instruction (Strauss, 2005, 2012; Strauss & Ziv, 2012; Strauss et al., 2002). One natural question derives from this observation and is addressed in the present paper: Are young children natural teachers? i.e., can they communicate information efficiently?

This question can be addressed by quantifying the precision of verbal explanations (LeBlanc & Bearison, 2004; Ziv & Frye, 2004; Ziv et al., 2008). In fact, several researchers (Fuchs et al., 1996; Graesser, Person, & Magliano, 1995; Topping, Cambell, Douglas, & Smith, 2003) have defined normative procedures to identify fragments in discourse that have a clear pedagogical intention. These pedagogical episodes were defined according to the conventional definition of 'pedagogy' as explicit communication of information in terms of knowledge content of another individual (Csibra & Gergely, 2006; Roscoe & Chi, 2007). Pedagogical episodes included different behaviors (Fuchs et al., 1996; Graesser et al., 1995; Topping et al., 2003) such as helping behaviors, anchoring learning in specific examples, question answering and explanatory reasoning, amongst others. However, the precision of verbal explanations is severely confounded by language fluency, temperament and attention (Schulz & Gopnik, 2004; Steels, 2006). Hence, a more precise and uncontaminated way to probe teaching efficiency in children is necessary in order to address this question properly.