UCLA
UCLA Electronic Theses and Dissertations

Title

Cultural Transmission in the Real World: A Quantitative Study of Teaching and Cultural Learning in the Yasawa Islands, Fiji

Permalink

Author

Kline, Michelle A.

Publication Date

2013

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA

Los Angeles

Cultural Transmission in the Real World

A Quantitative Study of Teaching and Cultural Learning

in the Yasawa Islands, Fiji

A dissertation in partial satisfaction of the

Requirements for the degree Doctor of Philosophy

in Anthropology

by

Michelle A. Kline

2013

ABSTRACT OF THE DISSERTATION

Cultural Transmission in the Real World

A Quantitative Study of Teaching and Cultural Learning

in the Yasawa Islands, Fiji

by

Michelle A. Kline

Doctor of Philosophy in Anthropology

University of California, Los Angeles, 2013

Professor Robert T. Boyd, Chair

The human species is more reliant on cultural adaptation than any other species, but it is unclear how observational learning can give rise to faithful transmission of cultural adaptations. One possibility is that teaching facilitates accurate social transmission by narrowing the range of the inferences that learners make. However, there is wide disagreement about how to define teaching, and how to interpret the empirical evidence for teaching across cultures and species. The work presented here addresses central questions in the study of the evolution of teaching through the presentation of new data and a new theoretical framework for an evolutionary approach to the study of teaching.

Chapter 1 presents predictions about when teaching and non-vertical transmission may be adaptive, and uses interview data from Fijian villages to demonstrate that parents are more likely to teach in comparison to other kin, high-skill and highly valued domains are more likely

to be taught, and oblique transmission is associated with high-skill domains, which are learned later in life.

Chapter 2 reviews three major approaches to the study of teaching—mentalistic, culture-based, and functionalist—and shows how these definitions fail to structure the cross-cultural and cross-species study of teaching. This chapter proposes a new framework of teaching types based on the learning problems teaching can solve, and reinterprets the existing evidence for teaching in humans and other animals in this framework. This chapter discusses the implications of this new framework, including the roles of cognitive constraints and cooperative dilemmas in how and when teaching evolves. It also offers an explanation as to why some types of teaching are uniquely human, and discusses future research directions.

Chapter 3 applies this theoretical framework, develops an ethogram for identifying naturally occurring teaching behavior outside the laboratory, and presents quantitative data from focal follows with young children in Fiji to test predictions about the form and function of teaching behavior. These data demonstrate that, as predicted in Chapter 2, teaching is present in non-western societies, more common among close kin, and lower-effort teaching types are more common than higher-effort ones.

The dissertation of Michelle A. Kline is approved.

Susan E. Perry

H. Clark Barrett

Brenda Bowser

Robert T. Boyd, Committee Chair

University of California, Los Angeles

2013

TABLE OF CONTENTS

Chapters

Figures

Tables

Bibliographies

ACKNOWLEDGEMENTS

I have benefitted from a superb committee of mentors whose advice has been thoroughly supportive but never too soft: Robert Boyd, Susan Perry, and H. Clark Barrett at UCLA, and Brenda Bowser at Fullerton. I am also grateful to Joan Silk and Joseph Henrich, who are not officially members of my committee but contributed enough time, effort, and resources to my work to constitute a second committee. In addition, I am thankful for the contributions of the faculty and graduate student members of the Experimental Behavioral Anthropology lab group and the Behavior, Evolution, and Culture group at UCLA, many of whom have listened to me talk for hours about various iterations of this work. Finally, thanks to my partner in the field and in pretty much everything there is to do or be, Matthew Gervais.

BIOGRAPHICAL SKETCH

Michelle A. Kline is a PhD Candidate in Biological Anthropology at the University of California, Los Angeles, where she also received her M.A. in Anthropology. She received her bachelor's degree in Anthropology and Political Science at SUNY University at Buffalo in New York. Her research addresses cultural transmission and the evolution of culture in humans, with an emphasis on cross-cultural and cross-species comparisons. Specific projects focus on the effects of demography on technological complexity in Oceania, the evolution of teaching, and links between health and culturally transmitted knowledge about diet in Fiji. Her work on the evolution of teaching earned the Human Behavior and Evolution Society Best New Investigator award in 2013. In addition to this work, she has published on the evolution of cooperation and strategic behavior. She has completed extensive fieldwork in Fiji and continues to work in villages there studying the coevolution of human culture and biology.

CHAPTER 1

Teaching and the Life History of Cultural Transmission
in Fijian Villages

Humans rely on cultural learning much more than any other animal species. Other animals primarily adapt to local environments through a variety of forms of individual learning. Each individual organism must acquire most of the knowledge it needs to thrive in the local environment on its own. In some species, social cues and even forms of scaffolding or teaching may facilitate the proliferation of local traditions (Caro and Hauser 1992; Hoppitt and Laland 2008; Thornton and Raihani 2008). However, they are limited to behaviors that individuals could learn on their own; there is no evidence of cumulative cultural change across generations, except perhaps for bird song. Humans acquire vast amounts of information from others by imitation, teaching, and other forms of cultural learning, and this leads to the cumulative evolution of complex local adaptations that no individual could learn on his or her own (Boyd et al. 2011).

Over the past several decades a number of researchers have developed a rich body of theory that analyzes the conditions under which natural selection will favor such a reliance on cultural learning, and how cultural learning should be structured (Boyd and Richerson 1985; Enquist et al. 2007; Feldman et al. 1996; Kameda and Nakanishi 2003; McElreath and Strimling 2008; Rendell et al. 2010; Rogers 1988; Wakano et al. 2007. Of particular interest here, this theory makes predictions about when individuals should learn from their parents as opposed to learning from others, and when teaching would be adaptive. We first review the theory on when to learn socially, and from whom, and then detail the predictions relevant to the current empirical study.

When to Learn from Others

A substantial amount of work (Boyd and Richerson 1988, 1996; McElreath and Strimling 2008; Perreault et al. 2012) indicates that natural selection favors social rather than individual learning when the behavior of others is a more accurate predictor of the best behavior in the local environment than alternative non-social cues. This will be true under at least two conditions. First, models show that when environmental cues vary in quality so they are only sometimes good indicators of the most adaptive behavior, selection can favor a psychology that causes individuals to learn selectively. Specifically, the most adaptive strategy is to learn individually when environmental cues provide clear guidance, but to learn from others when environmental cues are of low quality (Boyd and Richerson 1988; McElreath and Strimling 2008; Perreault et al. 2012). Second, other models assume that individual trial-and-error learning allows individuals to make small improvements cheaply, but not big ones. In these models, selection favors cultural learning, combined with occasional marginal improvements through individual learning (Boyd and Richerson 1985, 1996). In both cases, modest amounts of individual learning are sufficient to allow a population to accurately track changing environments, and thus the behavior of others provides useful information about the best behavior in the local environment. Qualitatively, this body of theory suggests that selection can give rise to an evolved psychology that includes both a strong intrinsic motivation to imitate others as well as motivations to independently discover and adopt novel adaptive behaviors.

Researchers have also addressed to whom learners should attend, when they do learn socially. Several different factors are likely to be important. First, a variety of cues may allow learners to identify models who are more likely to be behaving adaptively; successful individuals, widely copied individuals, older individuals, individuals whose behavior is more common, and individuals who resemble the learner in relevant dimensions are all examples (Boyd and

Richerson 1985; Henrich 2009; Henrich and Broesch 2011; Henrich and Gil-White 2001).

Second, the commonness of a behavior among models can provide a cue about which behaviors

are best (Henrich and Boyd 1998; Nakahashi et al. 2012). Finally, it may be more costly to copy

some individuals than others. Social learning takes time and requires access to the model

individual, which means that it will usually be least costly to copy parents, family members, and

others who are observed in the course of normal activities (Henrich and Broesch 2011).

When to Teach

One body of work evaluates when teaching is favored by natural selection (Cavalli-Sforza and

Feldman 1981; Hoppitt et al. 2008; Thornton and Raihani 2008). Here *teaching* is defined as

behavior that (*a*) is contingent on a naive observer being present, (*b*) is costly to the model, at

least in the short term, and (*c*) facilitates or speeds up the acquisition of behavior by the learner

(Caro and Hauser 1992). This definition includes a wide range of behavior from explicit

instruction to the model providing subtle cues that he or she intends the behavior to be copied.

Looked at this way, teaching is cooperative—more accurate learning benefits the learner but

costs the model. Thus, teaching can evolve only when the teacher can recoup fitness costs,

contingent on the pupil's improved learning (Hoppitt et al. 2008). If the model and the learner

are related, then inclusive fitness benefits can favor teaching (Cavalli-Sforza and Feldman 1981),

so all other things being equal, more teaching is expected among relatives than non-relatives.

There may also be direct fitness benefits to offset a teacher's costs. Learners can compensate

teachers through deference (Henrich 2009; Henrich and Gil-White 2001) or through reciprocity,

or teachers may reciprocally teach each other's offspring. Such reciprocal arrangements may be

especially effective when the cost of teaching increases only slightly as the number of learners

increases—and going from one to two pupils does not double the teacher's cost, for example.

Predictions about teaching depend critically on the costs to teachers and the benefits to learners. Researchers have argued that communication generally (Sperber and Wilson 1995) and cultural learning specifically (Gergely and Csibra 2006, 2011) is very difficult without ostensive cues provided by the model that narrow the range of possible inferences that learners can make. If this is true, very low cost teaching will yield very large benefits, and therefore we should expect such subtle teaching under a wide range of circumstances. Even low relatedness owing to viscous population effects may have been enough to endow humans with a psychology motivated to engage in subtle teaching directed toward any naive learner in their social group. For the same reason, indirect reciprocity could have easily supported the evolution of subtle, low-cost teaching. On the other hand, explicit instruction is often time-consuming and may require substantial modification of the teacher's behavior. For such high-cost types of teaching, the theory predicts that an evolved psychology should limit the behavior to close relatives, or to contexts in which the learners or their relatives provide the teachers with direct fitness benefits that compensate for the costs the teachers incur.

A common view in ethnographic work is that teaching is rare, if not uniquely Western (see Hewlett et al. 2011 for recent review). In contrast, evolutionary reasoning predicts that teaching should be common because our species' ability to adapt depends on faithful cultural transmission and teaching can be a powerful tool for increasing fidelity. We argue this conflict results from a mismatch of definitions: anthropologists typically equate teaching with Western-style instruction or schooling, whereas evolutionary theorists define teaching in terms of adaptive costs and benefits, with a broader behavioral profile (for applications to teaching in non-human animals, see Caro and Hauser 1992; Hoppitt et al. 2008). In this paper we adopt the evolutionary approach to the study of human teaching and show that it leads to a more sophisticated understanding of teaching's role in cultural learning.

When to Learn from Parents versus Others

This body of theory makes predictions about when selection should favor learning from parents (aka vertical transmission) and when it should favor learning from others ("oblique" and "horizontal" transmission). The following factors tend to favor learning from parents.

Cultural Variation in Fertility

When cultural variation causes variation in number of offspring (Aoki et al. 2011; McElreath and Strimling 2008), children who copy parents have a greater chance of acquiring cultural variants that increase family size than do children who copy randomly chosen adults. To see why, consider the following simplified example: Suppose that there are two culturally transmitted behaviors, and that mothers with one behavior produce three offspring, while mothers with the alternative behavior produce only one. Further suppose that children learn from their mothers and that the two behaviors are equally common. Three quarters of the children are in large sibships, and thus children who copy their mother have a 75% chance of acquiring the behavior that leads to large families. Children who copy random adult women have only a 50% chance. This effect will cause selection to favor cultural transmission when cultural variation has a substantial effect on variation in fertility, and the same variants do not have negative effects on other fitness components. (For example, cultural variants that lead to high fertility might also lead to high mortality.)

Low Levels of Cultural Variation

Cultural learning depends on access to models. If young children typically spend much more time with members of their family than with other adults, it will usually be cheaper for younger children to copy their parents and other members of the immediate family. Older children and adolescents typically interact with a wider range of adults, and it thus becomes less costly to copy non-family members. Because non-parental adults provide a large sample, adaptive

considerations suggest that, all other things being equal, children can benefit by being open to imitating such individuals. This predicts a two-stage model of cultural learning (Henrich and Broesch 2011; Hewlett et al. 2011; see also Aunger 2000). First, children learn from their parents and other members of their immediate family. As they get older, children compare what they have learned to the behavior that they observe among other individuals. If there is evidence that the novel behaviors are better, learners adopt them—vertical transmission first, then horizontal and oblique transmission. However, sometimes non-parental adults will provide no new information. There may often be little cultural variation among individuals in small-scale societies (Hewlett and Cavalli-Sforza 1986). The same may be true in larger societies that have reached cultural equilibrium. When new beneficial ideas are rare—for instance, because of rapid environmental change—imitating non-parents may provide big benefits (McElreath and Strimling 2008), but once they have spread through a society, learners can get them from their parents. These considerations predict that vertical transmission will be the norm in societies with limited cultural variation or for domains in which alternative cultural variants are equally attractive, and that a two-stage process will be common in societies or in domains with much cultural variation. The empirical record suggests that both patterns exist: vertical transmission is common in cross-species or cross-domain reviews (e.g., Hewlett and Cavalli-Sforza 1986; Shennan and Steele 1999), but there is evidence that oblique transmission is important in particular domains, such as ethnobotanical knowledge (Reyes-Garcia et al. 2009; see also Hill et al. 2009; Kaplan et al. 2000).

When Models Are Motivated to Deceive Learners and Conceal Information
The models and learners may often have divergent interests, and this means that learners may need to evaluate what models are trying to teach them (Sperber et al. 2010). For many traits this is not a problem because learners can observe models "practicing what they preach." If a learner observes a model frequenting a particular fishing ground, then the learner can be reasonably

certain that the model thinks that location is a fruitful one. More generally, if models can be seen exhibiting individually costly behavior consistent with a particular belief, then learners can reasonably infer that the model is not trying to deceive the learner (Henrich 2009). If a learner observes a model expending considerable effort to reach his preferred fishing grounds, this might be better evidence of the model's true belief in the location's value. Nonetheless, there are also situations in which detecting deception is difficult; some kinds of cultural learning depend on the testimony of models (Jaswal et al. 2010; Koenig and Harris 2007), and models may be motivated to lie to learners in order to increase their own fitness. Because parents' fitness depends on their offspring's success, parents may be the most willing and trustworthy models. This is true for other close relatives to a lesser extent. In contrast, especially attractive models may require learners to pay for access with resources, labor, or deference, as is often true of apprenticeships (Coy 1989).

Present Study

As part of a long-term study of life in rural Fijian villages, we performed a series of interviews designed to evaluate specific hypotheses about the roles of teaching and non-vertical transmission in cultural learning based on the theory outlined above. We tested three predictions about the distribution of teaching as a type of cultural learning.

1. *Teaching is most common among closely related kin, and least common where no genetic relatedness exists, all else being equal.* As a result, teaching should be more closely associated with vertical transmission than with oblique transmission.

2. *Domains that are more difficult in terms of skill—but not in terms of strength—should be associated with higher rates of teaching.* The adaptive value of teaching depends on how much the learners gain from tutelage—the gains from teaching should be greater for tasks that are more difficult to master.

3. *A domain's importance will be positively associated with frequency of teaching.* Teaching should be most frequent where its impact on fitness is the greatest. As a proxy for impact, we use a measure of a domain's importance to achieving success and respect in village life.

We also tested three predictions about the distribution of vertical, horizontal, and oblique pathways of cultural transmission based on the body of theory discussed above.

4. *Vertical and horizontal transmission will be negatively associated with the age at which a domain is first learned, whereas oblique transmission will be positively associated with start age.* According to the two-stage model of cultural learning, learning that takes place early in life is likely to be based on models that are easily accessible, including parents and close kin. In contrast, domains learned later on may be learned from a broader array of acquaintances.

5. *Low-skill domains will be associated with lower start ages, whereas high-skill domains will be associated with higher start ages.* The two-stage model of cultural learning suggests that basic skills are learned early in life, and later updated when a learner's access to models and experiences expands. Low-skill domains will not require updating and so will be associated with early learning ages. In contrast, high-skill domains may be learned later in life to begin with, and may be continuously updated throughout the life span, resulting in later reported learning ages.

6. *Domains requiring greater skill—but not greater strength—will be associated with higher levels of oblique transmission.* Domains for which there is less variation within a population—low-skill domains—can be learned from nearly any adult model so are likely to be learned from those close at hand, primarily parents or close relatives. In contrast,

8

there is likely to be greater variation in competence for high-skill tasks, so they are better learned from particular models, perhaps experts.

Methods

We collected data about children's day-to-day lives, ways of learning, and expected work contributions to their households. Here we give a detailed explanation of the field site and interview methods for three interviews: Domains of Success, Child Learning Interview, and Difficulty Ranking Task. All participants were recruited based on a random sampling of adults drawn from a demographic database; participants did not receive direct compensation for these interviews.

Ethnographic Context

Data presented here were collected during 2008–2011 in three Fijian villages on Yasawa Island, located in the northwestern corner of the Fijian Islands. These villages are sustained by a primarily subsistence economy, with 23% of calories coming from the market economy (Henrich et al. 2010a), and only 2 of 84 adults in Teci and Dalomo villages in 2010 reporting work in wage labor. Wage labor is more common in Bukama village, which lies about 30 minutes' walk from the island's only resort. Both men and women sometimes emigrate for jobs in the tourist industry, or other forms of wage labor.

Political units are composed of interrelated patri-clans, governed by a council of elders and a hereditary chief, and life is organized by a complex web of kinship relations and obligations. Each village has its own dialect. There are no local markets, broadcast television, automobiles, or public utilities in these villages, whose populations are about 100–250. Radios are common and cell phones have become increasingly prevalent since 2009, though a lack of a reliable source of electricity, unreliable service, and the difficulty of purchasing additional minutes limits

9

their usage. Despite the introduction of British-style formal schooling in the early 1900s (see White 2007), Fijian childhood in these relatively traditional villages remains quite different from childhood in the Western world, making for a valuable cross-cultural comparison of cultural learning. This paper focuses on Fijian adults' explanations of how children learn skills and behaviors that are important to success in a traditional Fijian village, including who they learn from, at what ages, and how. For additional ethnographic detail, readers should refer to the supplemental materials from Henrich and Henrich (2010b) and Henrich and Broesch (2011).

In this and many other Fijian villages, social interactions including those relevant to cultural learning are shaped by the relative social status and kinship relationships of the actors (Brison 1999; Nayacakalou 1975; Ravuvu 1983; Sahlins 1962; Toren 1990). As in many of the traditional societies mentioned above, relationship norms structure interactions so that subordinates do not dominate an interaction or set its terms by direct questioning (Arno 1990; Nabobo-Baba 2006). This is a recurring pattern in Polynesia (e.g., Borofsky 1987; Ritchie and Ritchie 1979). Many village rules about hierarchy do not apply to infants and very young children, who are thought to be incapable of comprehension. According to Hocart's study in the Lau region of Fiji, infants are said to be "without minds," and young children are "watery-souled" (Hocart 1929:146). As a result, Hocart reports that children are not expected to learn *tabu* (taboos) such as the ban on interaction with parallel cousins until the age of 7. In present-day Yasawan villages, adults say children should learn this tabu by 12–13 years of age (see ESM, pp. 1–2).

As is typical in the Pacific (Ritchie and Ritchie 1979) and across the world, Fijian parents are not expected to actively instruct very young children (see also Ochs and Schieffelin 1984), children are not encouraged to ask questions, and they are expected to contribute to household chores from the age of 7–8 (see "milestones" in the ESM; see also Bock 2002; Lancy 2008; Lancy and Grove 2011, cf. hunter-gatherer groups: Hewlett and Lamb 2007). In traditional villages in Fiji,

legitimate ways of learning include learning (*a*) by listening either to an established elder's telling or chatting *(talanoa)* or to rules as frequently repeated by parents (Nabobo-Baba 2006), and by experience, either (*b*) as a helper who is sometimes corrected (Ritchie and Ritchie 1979), or (*c*) individually, through pseudo-experimental trial-and-error (Nabobo-Baba 2006). Participants in our interviews occasionally mentioned schooling as a means of learning, and most children in the village attend primary school somewhat regularly between the ages of 7 and 14. Most adults in the population have completed primary school or have some secondary school education. However, as elsewhere in Fiji, parents in these villages seem to think of schooling mainly as a means for gaining future employment through fluency in English, rather than for success within traditional village life or as a goal that is valuable in itself (Brison 2007; Veramu 1992), so villagers generally rate more-educated individuals as having less knowledge of important domains of work within the village (Henrich and Broesch 2011). Children must still fulfill an economic role in the household, with priority apparently given to chores over homework (Dakuidreketi 2006; Veramu 1992). This suggests that though formal schooling is admired by many in Fiji, growing up in a Yasawan village is still quite different from growing up in a typical Western, educated, industrialized, rich , democratic society (see Henrich et al. 2010b for comparisons between "WEIRD" societies and others).

Domains of Success Interview

To document which domains are the most important for success in village life, we conducted interviews with a randomly selected sample of adults (*n* = 72), drawn from three villages on Yasawa Island—Teci, Dalomo, and Bukama. In this interview, we asked participants: (Q1) "What are the areas of skill, knowledge or success that make one a well-respected member of the community here?" We also asked participants (Q2) to tell us the most important areas of life for a boy to learn, and (Q3) the same for a girl. Finally, we asked (Q4) how children learn these skills, and (Q5) what aspects of life parents teach to their children. We use data from this

interview in three ways, and review each below. The interview script and additional results are published in Henrich and Broesch (2011). This interview was completed in Teci and Dalomo villages in 2006–2007, and Bukama village in 2009.

First, we used answers to Question 1 make a list of target domains for our Child Learning Interview. This interview was completed in Teci and Dalomo village in 2006–2007, and in Bukama village in 2009. From the list of domains participants mentioned, we selected all those domains that must be learned, eliminating inherited traits (e.g., chiefly status), personality attributes (e.g., kindness), or formal/governmental institutional domains (church and schooling). We eliminated personal attributes because Yasawans view some aspects of personality as biologically inherited (see Moya et al., in prep), and we are focused here on socially learnable domains. We also eliminated domains that were so general as to make it infeasible to ask questions about stages of learning, or degree of difficulty (for instance, *sasamaki*, a term which means "cleaning" in general and encompasses a number of more specific chores). To the remaining list, we added two domains we knew to be high skill, and that not every villager is expected to master: captaining a boat (*kavetanitaki ni boto;* males) and traditional medicine (*wainimate vakaviti;* females, includes mostly ethnobotanical medicines). Our final list includes eight target domains. For males, the remaining domains are farming (*laulau;* horticulture including cassava, yams, and fruits), traditional house-building (*tara sue*), and diving (*riu*). For females they are reef gathering (*vivili*) , mat-weaving (*tali loga*), and cooking (*vakatoko*).

Second, we used responses about which domains are most important for boys and girls to learn (Q2 and Q3) in order to calculate an "importance to success" variable for each of our target domains. We calculated *importance* as the total number of times a given domain was mentioned in response to Q2 and Q3 (see Table 1-1). The mean importance score is approximately 27 and

the standard deviation is 9.3; the highest possible score is 72. Traditional medicine and boat captaining were never mentioned, so they received scores of zero. We suspect that participants neglected to list these domains because only a few men and women in the village master them, so they are not prerequisites for achieving success even if mastering them might be sufficient to command respect among villagers (see Henrich and Broesch 2011).

Domain	Importance	Gender
Farming	65	M
Weaving	53	F
Cooking	51	F
Diving	23	M
House-building	19	M
Reef gathering	8	F
Traditional medicine	0	F
Captaining boat	0	M

Table 1-1. Target domains of success, the number of participants who listed each domain as important, and the gender category to which the task typically belongs.

Finally, we coded responses to Question 4 in terms of the process by which children learn. We coded for 5 possible learning processes: (1) hearing/listening (*rogoca*), (2) seeing/observing (*tolavia/raica*), (3) doing/practice (*cakava, vuli tara, vakatovotovotaka*), (4) imitating (*muria*), and (5) being taught. Terms coded as *being taught* include Fijian terms that translate as "taught" (*vakavulica*), "told" (*tukuni vua, talanoataki*), "corrected" (*vakadodonutaki*), or "shown" (*vakaraitaki vua*). Of 72 participants, 75% (*n* = 54) named at least one learning process. Many participants listed more than one learning process, for a total 101 listed learning processes. Some participants described specific learning processes for particular domains, rather than replying generally about all domains. We developed the Child Learning interview with a focus on documenting this type of domain-specific variation in the processes, sources, and life history trajectory of cultural learning.

Child Learning Interview

In a structured interview in 2009, we asked a random sample of adults in Teci and Dalomo villages (*n*=44; 21 male) questions about how boys and girls learn different skills that are crucial to success in village life, from whom they learn, and at what age. We asked specifically about the eight target skills from the Domains of Success interview. We also asked about the expected ages for a number of developmental milestones, as well as more open-ended questions about what sort of work children should do for the household, and at what ages (see ESM).

We present several types of data from this interview. First, participants were asked eight questions in the format "How does a boy/girl learn to do X?" where X is one of the target domains. The question is intentionally vague, so participants could name a process of learning (see/hear/do/imitate/teach), a source or pathway of transmission (parents/grandparents/friends/elders), or both. Participants were not compelled to answer in terms of social learning, but most did. Participants could have provided no, one, or more than one pathway of transmission and/or process for each domain about which we asked. Three participants never suggested any pathways of transmission so were dropped from these analyses. We collected 293 responses about transmission pathways for the target domains. The minimum number of responses about pathways for any domain in our sample was 34 and the maximum was 38. For responses about processes of learning, we collected 105 instances. The minimum number of responses about process for any domain in our sample was 9 and the maximum was 17. To code processes of learning, we used the same coding scheme as in the Domains of Success interview. To transform data on sources of learning into data on pathways of transmission, we coded learning from parents and grandparents as "vertical" transmission, learning from peers or siblings as "horizontal" transmission, and learning from more distant relatives, elders, villagers, experts, and others as "oblique" transmission. Because horizontal learning was so rarely reported, we did not distinguish between learning from siblings and from other peers.

For both the process and pathway data, we calculated the frequency of our focal variable (e.g., vertical transmission) over all relevant responses (e.g., all responses mentioning any source of learning), per domain. This created the *pathway* variables: frequency of vertical, oblique, and horizontal transmission, and the *process* variables: frequency of transmission through seeing, hearing, doing, imitating, or by teaching. For data on the rates of teaching by kin category, we calculated the number of times teaching was mentioned in conjunction with that kin type, divided by the total number of times that kin type was mentioned as the source or pathway of learning in conjunction with any process of learning, for each domain.

We also asked, for each target domain: "At what age should a boy/girl begin to learn to do X?" We use these data as "start age" estimates for the target domains. In a separate open-ended question, we asked: "What type of work should a boy/girl do for the household? At what age should they begin?" Participants provided as many domains of work as they pleased, along with an age estimate. We use these data as "start age" estimates for 10 additional domains. We also asked participants about whether there is anything that parents "should directly teach " *(e dodonu me vakatavulica ga)*, whether there is anything boys and girls must learn from peers, and whether there is anything that boys and girls must learn from adults other than their parents (see ESM). The question on teaching was asked using a Fijian translation for "teach" (*vakavulica*) that is roughly equivalent to the everyday use of the word in English. Literally, *vakavulica* translates as "cause to learn it." This meaning is achieved by using a causative particle, *vaka,* and the transitive form of the base that means "learn" (*vulica*). In contrast, the response "learn by doing" is *vuli tara,* translating literally as "learn-do." We used the Fijian intensifier "directly" (*ga*) in order to encourage participants to focus on the act of teaching rather than the expected general influence of adults on children's learning. This treatment of teaching is meant to parallel what anthropologists mean by teaching.

15

Difficulty Ranking Interview

We used responses from the Child Learning interview to create an inclusive list of domains to be learned, including the eight target domains and any categories of work listed in response to the open-ended question about types of work children should do for the household. We then asked randomly selected adult participants (*n*=16) to rank these 25 tasks according to difficulty in terms of (*a*) skill and (*b*) strength. Since these participants are not familiar with pen and paper rankings, we used a stack of index cards with task names printed on them and guided participants through a series of forced pair-comparisons for each successive domain. The end result is a linear ranking from most difficult to least difficult. Participants were then asked to look over the entire ranking from "high difficulty" to "low difficulty" and were permitted to make changes. Finally, we recorded the ranks on a paper data sheet. The index cards were shuffled between tasks, and the order in which participants did the skill and strength difficulty rankings was counterbalanced. We use the mean skill and physical difficulty rankings per domain in our analyses, reverse-scored so a larger number indicates higher difficulty, with a possible range of 1 to 25.

All three interviews were translated and back-translated by research assistants who are native speakers of Standard Fijian. The interviews were administered with the help of these research assistants. Some of the terms used for the difficulty ranking task were in the local Teci dialect of Fijian, which differs from Standard Fijian. The first author coded responses to the Domains of Success and Child Learning interviews using both the original Fijian responses as well as English translations done by research assistants. She resolved discrepancies in translation using Gatty's (2009) Fijian to English dictionary when necessary.

Results

We combined data from the Domains of Success, Child Learning, and Difficulty Ranking interviews to test key predictions drawn from theory on the evolution of teaching and social and cultural learning. First, we focus on predictions about the prevalence and strategic use of teaching. Second, we examine the roles of vertical and oblique transmission with respect to the two-stage model of cultural learning.

Teaching

We found substantial variation in reports of teaching across the domains we studied. In the Child Learning interview, across all eight target domains, we found that teaching was listed as a learning process on average 42.6% of the time, ranging from 21.4% for boat piloting to 66.6% for mat weaving. This is roughly equivalent to the cross-domain average for learning by "seeing" (43.3%), which was the most common process of transmission listed for boat piloting (78.6%), farming (tied with "doing" at 41.7%), house-building (52.9%), and traditional medicine (tied with teaching at 44.4%). In our Domains of Success interview, in which we only asked *generally* how children learn important skills or knowledge, participants named teaching as a process less often (17.8%) and were more likely to list "seeing" (33.6%) or "imitating" (22.7%). Learning by doing was also a common response (18.8%). These results demonstrate that teaching rates are variable across domains, even if teaching is generally rare.

We also asked participants whether there are things parents must teach their children directly. The most common response, made by 42 of 44 participants, translates as the "customs/ways of the people of the land" (*i tovo/i valavala vakavanua*) and refers generally to knowledge of ritual traditions, and respectful behavior expected from those living in a Fijian village. Participants could name more than one domain, and the next most common response was "ways of dress" (*sulusulu, n* = 13). All other responses were named by fewer than 10 participants: to speak well

(*vosavosa vinaka; n* = 8), school-related behaviors or habits (*vuli, n* = 5), church or religious

beliefs (*lotu, n* = 5), hairstyles (*kotikoti, n* = 4), knowledge of kinship or relatives (*veiwekani, n*

= 2), and "to listen," which sometimes implies both listening and obeying (*rogoca*, *n* = 2). In a

follow-up question in the same interview, many participants said that if parents did not teach

these things to their children, the results could be social conflict, drug use, and even jail time.

None of the target domains was mentioned even once in response to this question, despite the

relatively high reported rates of teaching when we asked specifically about how each domain is

learned. This illustrates the importance of using a variety of interview approaches.

To test hypothesis 1, we examined the relationship between the frequency of vertical, horizontal,

and oblique transmission and the frequency of teaching, using linear regressions on data for the

target domains (Table 1-2). Frequency of teaching is measured as the number of times teaching

was mentioned over the total number of transmission process mentions. As predicted, we found

that domains that are more likely to be transmitted vertically are also more likely to be taught

(Figure 1-1A), and that domains that are more likely to be transmitted obliquely are less likely to

be taught (Figure 1-1B). We found no effect for horizontal transmission on teaching rates—this is

expected given the rarity of horizontal transmission for the target domains.

| IV	Coeff.	p	R²	Bootstrap SE
% vertical transmission	0.38	0.03	0.59	0.13
% oblique transmission	−0.32	0.05	0.51	0.14
% horizontal transmission	−0.41	0.31	0.17	1.95

Table 1-2. Results of linear regressions predicting teaching rates for each domain (*n*=8) from rates of transmission by a given pathway within each domain. Bootstrap standard errors are based on 10,000 repetitions.

1A   Vertical Transmission

1B   Oblique Transmission
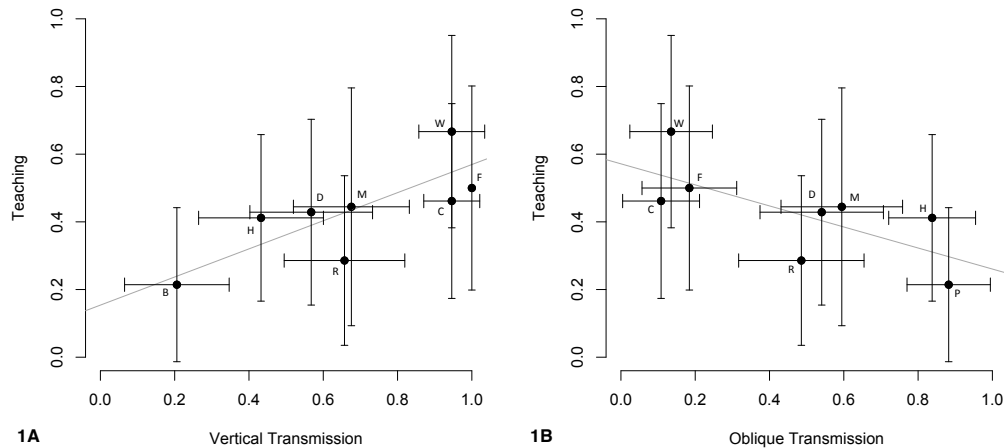
Figure 1-1. (A) Results of a linear regression predicting rates of teaching from rates of vertical transmission. (**B**) Results of a linear regression predicting rates of teaching from rates of oblique transmission. Data for both graphs are based on 8 domains, and bars represent standard error. Letters indicate particular domains. B = boat piloting, H = house-building, D = diving, F = farming, R = reef gathering, M = Fijian medicine, C = cooking, and W = weaving.

We also examined whether relatedness between teacher and pupil is positively associated with rate of teaching. We found that parents were the most likely to teach, with teaching mentioned 74.3% of the time that parents were listed as a source of social learning (n = 250). Elders were the next most common teachers (50%, n = 85), followed by grandparents (43%, n = 53), and experts (33.3%, n = 59) and peers (33.3%, n = 36). Formal schooling (n = 7), villagers in general (n = 6), siblings (n = 2), uncles (n = 2), and other individuals (n = 3) were never associated with teaching (Figure 1-2). In calculating these figures, we treated responses with no mention of pathway as missing data. Only parents were positively associated with teaching at a statistically significant level (χ^2= 16.98, p = 0.00). We also tested for an overall effect of genetic relatedness on the rate of teaching across all kin types. Three levels of relatedness are represented in the kin

types participants offered: r = 0.50 (parents), r = 0.25 (siblings, grandparents), and r = 0, or background relatedness (elders, experts, peers, villagers in general, school, others). Testing across these kin types (n = 9) using a linear regression, we did not find that relatedness predicts teaching rates (Coeff. = 44.15, p = 0.35, R^2 = 0.13). The results do not change qualitatively if we cluster our analysis according to the transmission pathway for each kin type, or if we control for pathway of transmission using dummy variables.
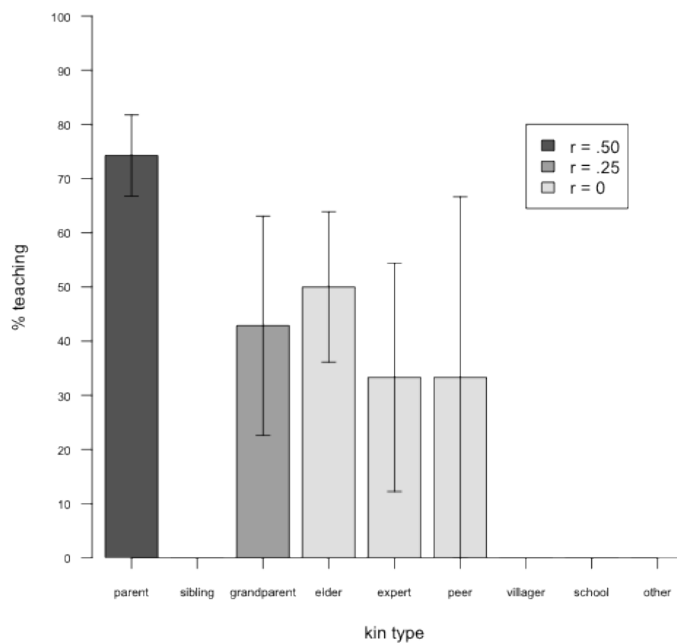
Figure 1-2. Rates of teaching, for each kin type. Typical genetic relatedness (r) for a kin type is indicated by shading. Bars represent standard error.

For hypothesis 2, we tested whether high-skill domains were positively associated with teaching, using linear regressions on data for the target domains. Because small sample sizes render p values unreliable, we also calculated the bootstrapped Standard Errors. We found that neither skill difficulty nor strength difficulty ratings alone predict a greater role for teaching (Table 1-3). However, when we control for the pathway of transmission by including the rate of vertical transmission in the models, the coefficient for skill difficulty dramatically increases in size, and the p values become marginally significant. In addition, the bootstrapped SE suggests our

findings are statistically significant, and the regression accounts for 77% of the variation. As expected, controlling for transmission pathway does not alter the results for models of physically demanding tasks, and none of the results we present here change qualitatively if we control for rate of oblique transmission rather than vertical transmission. Controlling for domain importance does not change the outcome of the models. However, boat piloting is an outlier in the skill difficulty model, and removing boat piloting improves the model results (see caption, Table 3). This may be because, like learning to drive a car, learning to drive a boat requires automatizing a number of complex, embodied routines. Thus actually learning to drive the boat requires hours of practice, whether or not certain principles are taught.

For hypothesis 3, we investigated whether the importance of a domain is associated with higher rates of teaching, using linear regressions based on data for our target domains. As predicted, we found that the importance of a domain to success in village life is a strong predictor of rates of teaching (Table 3). Controlling for importance does not improve the regression models testing the effects of skill difficulty on teaching rates.

| Independent Variables	Coeff.	p	R^2	Bootstrap SE	β
skill difficulty	0.00	0.50	0.08	0.02	0.28
physical difficulty	−0.00	0.97	0.00	0.01	−0.01
importance to success	0.00	0.04	0.54	0.00	0.73
skill difficulty	0.01	0.10	0.77	0.04	0.43
% vertical transmission	0.41	0.01		0.19	0.85
skill difficulty	0.01	0.56	0.57	0.02	0.18
importance to success	0.00	0.06		0.00	
physical difficulty	0.00	0.65	0.61	0.04	0.14
% vertical transmission	0.39	0.04		2.52	
physical difficulty	−0.01	0.43	0.60	0.07	−0.26
importance to success	0.00	0.04		0.01	0.81

Table 1-3. Results of linear regressions predicting teaching rates per domain ($n=8$) from skill and physical difficulty per domain, and from the domain's importance to success. Bootstrap standard errors are based on 10,000 repetitions. Without boat piloting in the sample, the regression of teaching on skill difficulty improves ($r=0.01$, SE=0.007, $p=0.11$; $n=7$).

Life History and Pathways of Transmission

We now evaluate three additional hypotheses based on the two-stage model of cultural learning.

Here, we use logistic regressions with individual-level data on the target domains to test

whether the age at which a domain is first learned affects the probability of its being learned

through a particular pathway of transmission—vertical, oblique, or horizontal (Table 1-4). As

predicted by hypothesis 4, we found that domains that are learned later in life are less likely to

be transmitted vertically and more likely to be transmitted obliquely (Figure 1-3). Horizontal

transmission remains rare compared with oblique and vertical transmission and has a weak

negative association with start age. Responses that included no information about transmission

pathway were treated as missing data, so 3 participants were dropped and responses from 41

participants were included. We calculated bootstrap standard errors using 10,000 repetitions.

Dependent variables	OR	p	Pseudo R2	Bootstrap SE
Probability of vertical transmission (clustered by domain) (clustered by individual)	0.83	0.00 (0.00) (0.00)	0.08	0.03 (0.04) (0.04)
Probability of oblique transmission (clustered by domain) (clustered by individual)	1.16	0.00 (0.00) (0.00)	0.07	0.04 (0.05) (0.06)
Probability of horizontal transmission (clustered by domain) (clustered by individual)	0.91	0.05 (0.01) (0.02)	0.02	0.04 (0.04) (0.04) (0.04)

Table 1-4. Results from logistic regressions predicting rates of transmission by a given pathway within each domain (n=8) from the age at which each domain is first learned. DV = dependent variables and IV = independent variables. Bootstrap standard errors are based on 10,000 repetitions. Both bootstrap SE and p values are clustered first by domain (n=8) and then by participant (n=41).
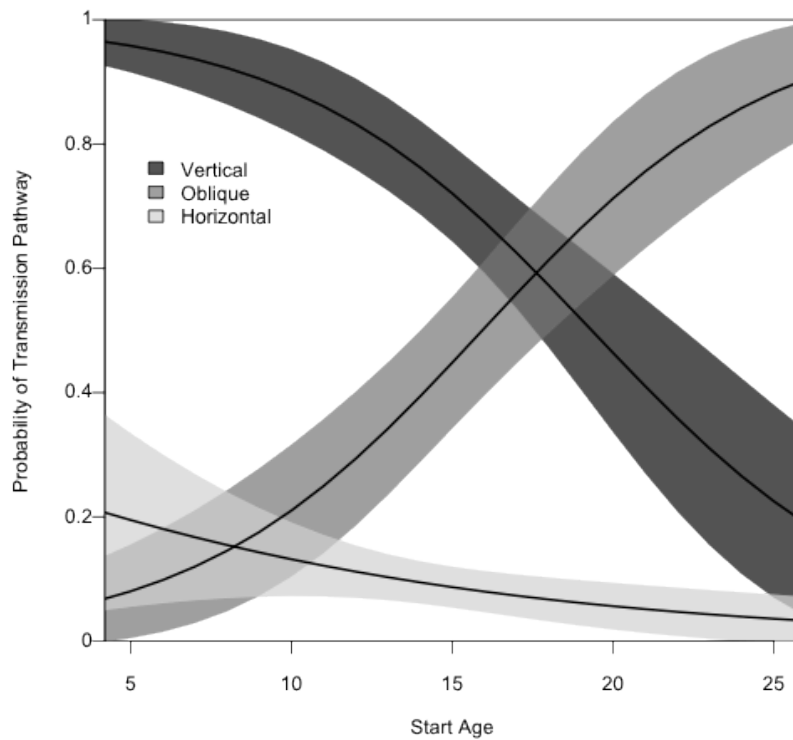
Figure 1-3. Results of a logistic regression predicting the probability of transmission by three possible pathways from the age at which individuals start to learn a task, clustered by individual. Pathways are distinguishable by shading, which represents 95% confidence intervals.

To test hypothesis 5, we used linear regressions to examine the effect of skill and physical difficulty on the age at which children begin to learn a given domain (Table 1-5). We found that later start ages are associated with tasks requiring greater skill, but not with tasks requiring greater physical strength (Figure 1-4). We used estimates of starting age (n = 499) for 18 domains of learning, including our eight target domains. We also calculated bootstrap standard error using 10,000 repetitions.

Dependent variables	Coef.	p	R2	Bootstrap SE
Skill difficulty	0.59	0.00	0.23	0.05
(clustered by domain)		0.00		0.15
(clustered by individual)		0.00		0.06
Strength difficulty	-0.01	0.89	0.00	0.05
(clustered by domain)		0.97		0.18
(clustered by individual)		0.86		0.04

Table 1-5. Results for linear regressions predicting skill and strength difficulty of each domain from the age at which each domain is first learned. Bootstrap standard errors are based on 10,000 repetitions. Bootstrap SE and p values are clustered first by domain (n=8) and then by participant (n=41).

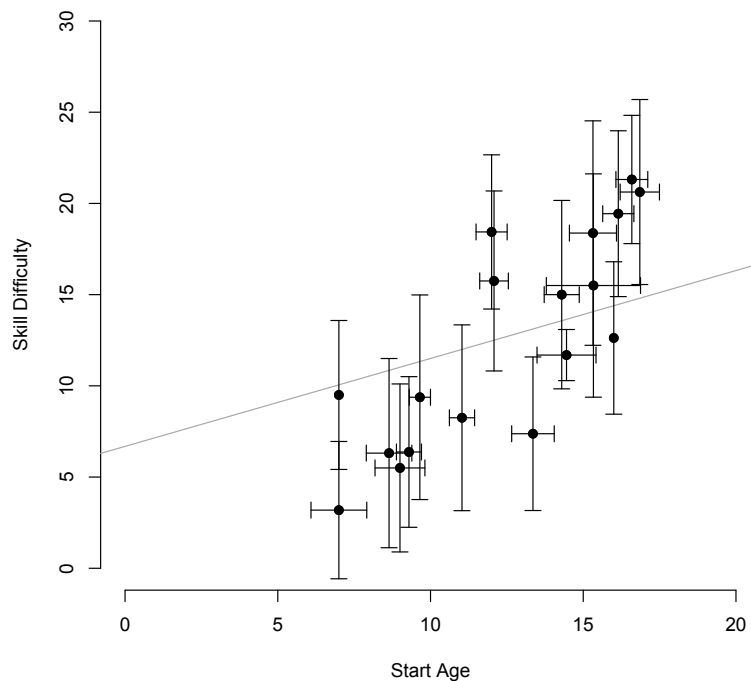**Figure 1-4.** Results of a linear regression predicting skill difficulty for each domain (n = 18) from the age at which individuals start to learn them. Regressions are based on 499 start age estimates, but we plot only the mean of each domain here. Bars represent standard error.

Finally, we used logistic regressions to test hypothesis 6, on the effect of skill and physical difficulty on the probability of the target domains being transmitted through a given pathway (Table 1-6). We found that vertical transmission is common for tasks of all skill levels, but less so as task difficulty increases. In contrast, oblique transmission is unlikely for low-skill tasks and becomes more likely with increasing task difficulty. Horizontal transmission is common for low-skill tasks but quickly becomes rare as task difficulty increases (Figure 1-5). Participants could

and often did name more than one pathway of transmission per domain. This suggests that multiple pathways of transmission are often active for a single domain, and that the pathways are not mutually exclusive. As a result, the probabilities for all three pathways do not sum to 1. Three participants did not provide any information on transmission pathways, so the analysis was based on 293 responses from 41 participants. To correct for non-independence of data, we clustered our analyses first by domain and then by individual. We calculated bootstrap standard error using 10,000 repetitions.

IV	DV	OR	p	Pseudo R2	Bootstrap SE
Skill difficulty	Probability of vertical transmission (clustered by domain) (clustered by individual)	0.96	0.17 0.62 0.17	0.01	0.01 0.05 0.01
Skill difficulty	Probability of oblique transmission (clustered by domain) (clustered by individual)	1.16	0.00 0.00 0.01	0.07	0.01 0.05 0.01
Skill difficulty	Probability of horizontal transmission (clustered by domain) (clustered by individual)	0.79	0.00 0.00 0.00	0.19	0.03 0.21 0.03
Strength difficulty	Probability of vertical transmission (clustered by domain) (clustered by individual)	0.97	0.13 0.61 0.10	0.01	0.02 0.12 0.02
Strength difficulty	Probability of oblique transmission (clustered by domain) (clustered by individual)	1.05	0.02 0.52 0.01	0.01	0.02 0.08 0.02
Strength difficulty	Probability of horizontal transmission (clustered by domain) (clustered by individual)	0.96	0.22 0.63 0.22	0.01	0.03 0.23 0.03

Table 1-6. The results of logistic regressions predicting the probability of transmission by a given pathway within a domain from the skill and strength difficulty of each domain. Bootstrap standard errors are based on 10,000 repetitions. Both bootstrap SE and p values are clustered first by domain (n=18) and then by participant (n=41).
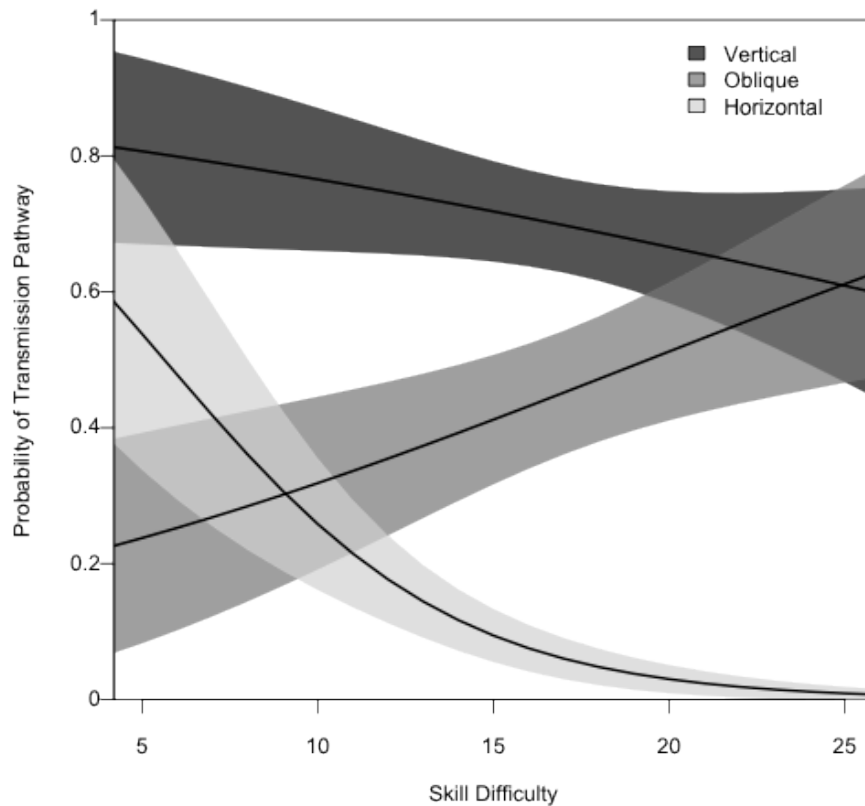
Figure 1-5. Results of a logistic regression predicting the probability of transmission by three possible pathways within a domain from each domain's skill difficulty ($n = 8$), clustered by individual. Pathways are distinguishable by shading, which represent 95% confidence intervals.

Discussion

Teaching Is Important

Our efforts illustrate the value of bringing specific evolutionary hypotheses to bear on the question of teaching. We found that teaching is more common than the existing ethnographic literature would (qualitatively) suggest—for instance, in discussions of "the absence of teaching" outside Western societies (Lancy and Grove 2010; see Hewlett et al. 2011 for review). Our findings are based on interviews about cultural learning in a fishing and horticultural village in the Yasawa region of the Fijian Islands. This region of the world contrasts with Western societies in that teaching is not a privileged way of learning, though there are formal schools. Our findings are in this sense surprising. Across village "domains of success," 43% of responses about process of transmission elected teaching. However, our findings are reconcilable with the existing literature on teaching, especially when considered in the light of the

26

evolutionary hypotheses we test. We found teaching was more common in domains that were more important to success in village life. Because our investigation was already limited to areas that villagers deemed important to success in village life, this may help to explain our generally high rates of reported teaching across domains. In addition, our rates may be higher than those in the existing literature on human teaching because we used a broad definition of teaching, including Fijian terms for being told, being shown, being corrected, and the literal translation of "teach." This approach focuses on the adaptive function of teaching—to facilitate learning in others—and is more like that used by researchers in animal behavior (e.g., Hoppitt and Laland 2008) than those used by either psychologists or anthropologists.

In the Child Learning interview we asked specific questions about how particular domains are learned, and as a result we obtained a number of different rates of teaching. In response to a more general question about how children learn in our Domains of Success interview, participants were much less likely to talk about teaching—82% of the learning processes named by participants were something other than teaching, which accounted for only 18% of responses. This replicates the qualitative claims in the anthropological literature on the rarity of teaching, using roughly the same methods on which claims about the "absence of teaching" are based. This suggests that our new findings on the importance of teaching are due to a more refined methodology rather than some unique feature of our field site. The discrepancy between reported rates of teaching for specific domains versus learning in general highlights one source of disagreement between theory and empirical research on teaching—while the theory focuses on the specific conditions under which teaching is adaptive and should therefore be common, the empirical record consists mostly of general claims made at the level of entire cultural groups.

Our data on teaching shows that its frequency is predicted by several factors. First, the identity of the potential teacher matters: vertical transmission is strongly associated with teaching, and parents are especially likely to teach. These findings are consistent with evolutionary predictions based on inclusive fitness and kin selection, despite the fact that we did not find a statistically significant main effect of relatedness on teaching rates. This may be because the open-ended nature of our questions resulted in only seven kin types being mentioned, and a significant effect is unlikely with such a small sample size. Alternatively, relatedness effects may in reality be small compared with the effects of proximity to

available teachers, domain skill level, age of the pupil, and the importance of the domain. A study that more specifically targets questions of who teaches whom, or one that includes the costs incurred by teachers, might clarify this result. We focused instead on open-ended questions about "how" children learn in order to allow participants to indicate that children learn-by-doing or through other non-social means.

We found evidence that tasks that are more difficult in terms of skill but not in terms of strength are more likely to be taught, controlling for transmission pathway. We also found that importance of the domain for success is a strong predictor of rates of teaching. These findings suggest that teaching should be most common in domains that are important for every child to master, and that are also difficult to learn. In short, teaching should be most prevalent in domains that have the greatest impact on the pupil's evolutionary fitness.

Non-Vertical Transmission Is Important

We found that domains for which learning begins early in life are more likely to be vertically transmitted, whereas domains for which learning begins later in life are more likely to be transmitted obliquely. Horizontal transmission was rare for our focal domains such that we were unable to distinguish peer versus sibling transmission, but children are expected to learn a number of social norms—such as style of dress and speech—horizontally (see ESM). This general pattern supports what has been called the two-stage life history of learning (Henrich and Broesch 2011; Hewlett et al. 2011), or the more general view that as patterns of social interaction change over the lifespan, so do sources of social and cultural learning, and the resulting patterns of cultural variation (Aunger 2000). This finding is important because it resolves the apparent contradiction between theory, which suggests that non-vertical transmission should be common, and the empirical record, which documents that in non-Western, small-scale societies, everything is learned from the parents. It also supports a more complex interpretation of the existing literature, suggesting that when people are asked "Whom did you learn X from?" they are likely to list the person they first learned from, without mentioning the people from whom they later learned additional skills. This explains why early research found such a strong role for parents—it is likely that participants

were thinking only of early learning experiences. By asking about societal norms and by including skills that are acquired later in life—such as traditional medicine, piloting a boat, and house-building—we were able to circumvent this issue and get a broader view of cultural learning across the life history.

We found that domains learned later in life were also more difficult in terms of skill, but not in terms of physical strength. This impacts the study of the life history of cultural learning in several ways. First, it suggests that the long juvenile period is not primarily an adaptation for learning high-skill tasks, since the most difficult tasks in terms of skill are learned the latest in life. Alternatively, high-skill tasks may come with many prerequisite skills, and those skills might be learned during the juvenile period. This does not rule out the juvenile period as an adaptation for learning other aspects of a complex cultural world, however, because our questions focused on tangible tasks such as horticulture, gathering, manufacturing artifacts, and other household work. On the other hand, it complicates the debate about whether skill or strength constrains children's subsistence efforts. It may be that for a given task, strength rather than skill limitations prevent a child from being as efficient as an adult (e.g., in reef gathering: Bird and Bliege-Bird 2002; Bliege-Bird and Bird 2002). However, this may be the case only because high-skill tasks are not attempted in early and middle childhood, so the skill constraint is demonstrated through *which tasks* children attempt rather than their performance in any particular task. Also, this explanation ought to apply equally to high-strength tasks—a trend which our data do not support. Finally, the delayed onset of learning complex skills, paired with the finding that such skills are more likely to be transmitted obliquely, suggests an alternative interpretation. If high-skill tasks are best learned from experts, and experts are rare and hard to approach, high-skill tasks may be learned later in life not only because of children's cognitive constraints but also because of social constraints in children's access to experts.

Conclusions

Overall, our findings support predictions made by theories of cultural evolution and the two-phase approach to the life history of cultural learning. We found that teaching was a strategic component of cultural transmission and was spontaneously offered by interviewees as one process of learning among many. We also found that patterns in the frequency of teaching can be explained by evolutionary reasoning—teaching is more common among kin, and when the expected benefits to the pupil are high.

And we found that vertical transmission is important, but not the only means by which key domains are learned. In fact, high-skill domains or domains learned late in life are learned primarily from non-parents. Given these findings, future research should focus on examining the trade-offs between the cost of teaching and the benefits that may be derived by the teacher—including kinship benefits or prestige deference exchange. In addition, researchers should focus on how different pathways of transmission correspond to changes in social interaction networks throughout the life history, and how these changes may affect the likelihood of teaching. Since teaching is in theory a cooperative problem (Thornton and Raihani 2008), further progress might be made in studying the social norms that promote or discourage teaching and other information-sharing behaviors (see Henrich 2009). Further, anthropologists and psychologists can benefit from the literature on teaching in non-human animals, and on research into the cognitive bases of teaching, both of which use evolutionary theory to classify different types of teaching. Since both these fields lack a thorough cross-cultural perspective on the range of teaching behaviors and the variety of situations in which humans do teach, ethnographers have a great deal to offer in return. This would lead to a richer, more accurate picture of cross-cultural variation in teaching and the life history of cultural transmission.

References

Aoki, K., Lehmann, L., Feldman M.W. (2011). Rates of cultural change and patterns of cultural accumulation in stochastic models of social transmission. *Theoretical Population Biology*, 79, 192-202.

Aunger, R. (2000). The life history of culture learning in a face-to-face society. *Ethos. 28*(3), 445-481.

Arno, A. (1990). Disentangling indirectly: The joking debate in Fijian social control. In (K. A. Watson-Gegeo and G. M.White, eds.) *Disentangling conflict discourse in Pacific societies* (pp 241-269). Palo Alto: Stanford University Press.

Bird, D. W., and Bliege-Bird, R. (2002). Children on the reef: Slow learning or strategic foraging? *Human Nature*, *13*(2), 269–297.

Bliege-Bird, R., and Bird, D. W. (2002). Constraints of knowing or constraints of growing? Fishing and collecting by the children of Mer. *Human Nature*, *13*(2), 239–267.

Bock, J. 2002. Learning, life history, and productivity: Children's lives in the Okavango Delta, Botswana. *Human Nature,* 12, 161-197.

Borofsky, R. (1987). *Making history: Pukapukan and anthropological constructions of knowledge*. Cambridge: Cambridge University Press.

Boyd, R. & Richerson, P.J. (1985). *Culture and the evolutionary process*. Chicago: University of Chicago Press.

Boyd, R., and P. J. Richerson. (1988). An Evolutionary Model of Social Learning: The Effects of Spatial and Temporal Variation. In: *Social Learning: A Psychological and Biological Approaches*, T. Zentall and B. G. Galef, eds., Lawrence Erlbaum Assoc., Hillsdale, NJ. pp 29-48.

Boyd, R. & Richerson, P. J. (1995). Why does culture increase human adaptability? *Ethology and Sociobiology,* 16, 125-143.

Boyd, R., & P. J. Richerson (1996) Why culture is common but cultural evolution is rare. *Proceedings of the British Academy: Evolution of Social Behaviour Patterns in Primate and Man*, 88, 73–96. http://www.britac.ac.uk/pubs/cat/pba88.cfm

Boyd, R., Richerson, P.J., & Henrich, J. (2011) The cultural niche: Why social learning is essential for human adaptation. *Proceedings of the National Academy of Sciences (USA), 108,* 10918-10925.

Brison, K. T. (1999). Hierarchy in the world of Fijian children. *Ethnology*, *38,* 97–119.

Brison, K. T. (2007). Imagining modernity in rural Fiji. *Ethnology, 42,* 335-348.

Caro, T., and Hauser, M. (1992). Is there teaching in nonhuman animals? *Quarterly Review of Biology*, *67*(2), 151-174.

Cavalli-Sforza, L.L., and M.W. Feldman. (1981). Cultural Transmission and Evolution: A Quantitative Approach (No. 16). Princeton University Press.

Coy, M. 1989. *Apprenticeship: From theory to methods and back again.* Albany: SUNY Albany
 Press.

Dakuidreketi, M.R. (2006). *Contexts of science teaching and learning in Fiji primary schools:*
 A comparative study of ethnic Fijian and Indo-Fijian communities. (Doctoral
 Dissertation). University of Canterbury School of Educational Studies and Human
 Development.

Enquist, M., Eriksson, K., & Ghirlanda, S. (2007). Critical social learning: A solution to Rogers's
 paradox of nonadaptive culture. *American Anthropologist, 109,* 727-734.

Feldman, M. W., K. Aoki, and J. Kumm. (1996). Individual versus social learning: Evolutionary
 analysis in a fluctuating environment. Santa Fe Institute Working Paper. Available
 online at http://www.santafe.edu/research/working-
 papers/abstract/158eef061eba1f42429d322426508c20/

Gatty, Ronald. (2009). *Fijian-English dictionary, with notes on Fijian culture and natural*
 history. Suva, Fiji: Oceania Printers.

Gergely, G. & G. Csibra. (2006). Sylvia's recipe: The role of imitation and pedagogy in the
 transmission of cultural knowledge. In (N.J. Enfield & S.C. Levenson, eds.) *Roots of*
 human sociality: Culture, cognition, and human interaction (pp. 229-255). Oxford:
 Berg.

Gergely, G. & G. Csibra. (2011) Natural pedagogy and an evolutionary adaptation. *Philosophical*
 Transactions of the Royal Society B: Biological Sciences, 366, 1149-1157.

Henrich, J. (2009). The evolution of costly displays, cooperation, and religion: Credibility
 enhancing displays and their implications for cultural evolution. *Evolution and Human*
 Behavior, 30, 244-260.

Henrich, J. & Boyd, R. (1998). The evolution of conformist transmission and the emergence of
 between-group differences. *Evolution and Human Behavior, 19,* 215-241.

Henrich, J., and Broesch, J. (2011). On the nature of cultural transmission networks: Evidence

    from Fijian villages for adaptive learning biases. *Philosophical Transactions of the Royal*

    Society B: Biological Sciences, *366,* 1139–1148.

Henrich, Joseph, and Gil-White, F. J. (2001). The evolution of prestige: Freely conferred

    deference as a mechanism for enhancing the benefits of cultural transmission. *Evolution*

    and Human Behavior, *22,* 165–196.

Henrich, J., & Henrich, N. (2010). The evolution of cultural adaptations: Fijian food taboos

    protect against dangerous marine toxins. Proceedings of the Royal Society B: Biological

    Sciences, 277, 3715- 3724

Henrich, J, Ensminger, J., McElreath, R., Barr, A., Barrett, C., Bolyanatz, A., Cardenas, J. C., et

    al. (2010a). Markets, religion, community size, and the evolution of fairness and

    punishment. *Science*, *327,* 1480–1484. doi:10.1126/science.1182238

Henrich, Joseph, Heine, S. J., and Norenzayan, A. (2010b). The weirdest people in the world.

    Behavioral and Brain Sciences, *33* (2-3), 61–83.

Hewlett, Barry S., and Cavalli-Sforza, L. L. (1986). Cultural transmission among Aka pygmies.

    American Anthropologist, *88,* 922–934.

Hewlett, B.S., and M.E. Lamb. (2007). *Hunter-gatherer childhoods: Evolutionary,*

    development, and cultural perspectives. New Brunswick, NJ: Aldine/Transaction.

Hewlett, B.S., Fouts, H. N., Boyette, A. H., and Hewlett, B. L. (2011). Social learning among

    Congo Basin hunter-gatherers. *Philosophical Transactions of the Royal Society B:*

    Biological Sciences, *366,* 1168–1178.

Hill, K., Barton, M., & Hurtado, A. M. (2009). The emergence of human uniqueness: Characters

    underlying behavioral modernity. *Evolutionary Anthropology*, *18,* 187–200.

Hocart, A.M. (1929). *Lau Islands, Fiji.* Honolulu: Bernice P. Bishop Museum.

Hoppitt, W., & Laland, K. (2008). Social processes influencing learning in animals: A review of

the evidence. *Advances in the Study of Behavior*. *38*, 105-165.

Hoppitt, W. J. E., G. R. Brown, R. Kendal, L. Rendell, A. Thornton, M. M. Webster & K. N. Laland. (2008). Lessons from animal teaching. *Trends in Ecology and Evolution, 23,* 486-493.

Jaswal, Vikram K, Croft, A Carrington, Setia, Alison R, & Caitlin A Cole. (2010). Young children have a specific, highly robust bias to trust testimony. *Psychological Science, 21,* 1541-1547.

Kameda, T. & Nakanishi, D. (2003). Does social/cultural learning increase human adaptability? Rogers's question revisited. *Evolution and Human Behavior, 24,* 242-260.

Kaplan, H., Hill, K., Lancaster, J., & Hurtado, A. M. (2000). A theory of human life history evolution: diet, intelligence, and longevity. *Evolutionary Anthropology, 9,* 156-185.

Koenig, M., & Harris, P. (2007). The basis of epistemic trust: Reliable testimony or reliable sources? *Episteme, 4,* 264–284.

Lancy, D. (2008). *Anthropology of childhood: Cherubs, chattel, changelings*. Cambridge University Press, Cambridge.

Lancy, D. and Grove, M.A. (2010). The role of adults in children's learning. In (D. F. Lancy, J. Bock, and S. Gaskins, eds.), *The anthropology of learning in childhood* (pp. 145-179). Lanham, MD: AltaMira Press.

Lancy, D. F., & Grove, M. A. (2011). Getting noticed: Middle childhood in cross-cultural perspective. *Human Nature, 22,* 281–302.

McElreath, R., and Strimling, P. (2008). When natural selection favors imitation of parents. *Current Anthropology, 49,* 307–316.

Nabobo-Baba, U. (2006). *Knowing & learning: An indigenous Fijian approach*. Suva: Institute of Pacific Studies Press.

Nakahashi, W., Wakano, J., & Henrich, J. (2012). Conditions for conformist transmission: Spatial variation and the number of cultural traits favors conformist biases over individual learning, unbiased transmission, and payoff-biased transmission. Human

Nature, 23, 386–418.

Nayacakalou, R. (1975). *Leadership in Fiji*. Melbourne: Oxford University Press.

Ochs, E., B. B. Schieffelin. (1984). Language acquisition and socialization. In (RA Shweder and RA Levine Eds), *Culture theory: Essays on mind, self, and emotion* (pp. 263-301). Cambridge: Cambridge University Press.

Perreault, Charles, Moya Cristina, and Boyd Robert. 2012. A Bayesian approach to the evolution of social learning. *Evolution and Human Behavior, 33,* 449-459.

Ravuvu, A. (1983). *The Fijian way*. Suva: University of South Pacific Press.

Rendell, L., Fogarty, L., & Laland, K. (2010). Rogers's paradox recast and resolved: Population structure and the evolution of social learning strategies. *Evolution, 64,* 534-548.

Reyes-García, Victoria, James Broesch, Laura Calvet-Mir, Nuria Fuentes-Peláez, Thomas W. McDade, Sorush Parsa, Susan Tanner, Tomás Huanca, William R. Leonard, and Maria R. Martínez-Rodríguez. (2009). Cultural transmission of ethnobotanical knowledge and skills: An empirical analysis from an Amerindian society. *Evolution and Human Behavior*, *30,* 274–285. doi:10.1016/j.evolhumbehav.2009.02.001

Ritchie, JB, and JE Ritchie. (1979). *Growing up in Polynesia*. Worthing, UK: Littlehampton Book Svc.

Rogers, A. R. (1988). Does biology constrain culture? *American Anthropologist, 90,* 819-831.

Sahlins, M.D. (1962). *Moala: Culture and nature on a Fijian island*. Ann Arbor: University of Michigan Press.

Shennan, S., and Steele, J. (1999). Cultural learning in hominids: A behavioural ecological approach. In (H. Box and K. Gibson, eds.) *Mammalian Social Learning: Comparative and Ecological Perspectives* (pp. 367-388). Cambridge: Cambridge University Press.

Sperber, D., F. Clement, C. Heintz, O. Mascaro, H. Mercier, G. Origgi & D. Wilson. (2010). Epistemic vigilance. *Mind & Language, 25,* 359–393

Sperber, D. & D. Wilson. (1995). *Relevance: communication and cognition,* second edition. Cambridge, MA: Blackwell.

Thornton, A., and N. Raihani. (2008). The evolution of teaching. *Animal Behaviour* 75:1823-1836.

Toren, C. *Making Sense of Hierarchy*. Atlantic Highlands: Athlone Press, 1990

Veramu, J. 1992. *Let's Do it Our Way: A Case Study of Participatory education in a Rural Fijian School and Community*. Suva: Institute of Pacific Studies Press.

Wakano, J. Y. & Aoki, K. (2007). Do social learning and conformist bias coevolve? Henrich and Boyd revisited. *Theoretical Population Biology, 72,* 504-512.

White, C.M. (2007). Schooling in Fiji. In (C Campbell and G Sherington Eds) *Going to School in Oceania* (pp. 79-132). Westport, CT: Greenwood Press.

CHAPTER 2:

How to learn about teaching

An evolutionary framework for the study of teaching behavior

in humans and other animals

The adaptive value of teaching

The human species is more reliant on cultural adaptation than is any other species (Boyd &

Richerson 1985, Hill et al. 2009, Boyd et al. 2011, Dean et al. 2012, Whiten & Erdal 2012). Much

of the knowledge and behavior that allows humans to adapt to a uniquely broad range of

ecologies is accumulated over multiple generations, leading to adaptations more complex than

any one individual could produce in a lifetime (Boyd & Richerson 1996, Tennie et al. 2009). For

example, Oceania was only settled through the combination of sophisticated navigational

knowledge, along with complex double-hulled canoes (see Kirch 2002)—and the Arctic could

not have been settled without new technologies for clothing and shelter, as well as food-getting

techniques (Boyd et al. 2011).

In culture as in biology, the accumulation of adaptive changes across many generations occurs

only when transmission is sufficiently faithful. A variety of mechanisms work to make genetic

replication incredibly accurate, but it is less clear what makes cultural transmission faithful, or

how much fidelity is necessary (see Dawkins 1982, Henrich & Boyd 2002, Henrich et al 2008).

The problem is that—unlike genes—cultural variants do not physically replicate. Instead, social

learning is an inferential process by which social learners use—among other inputs—others'

behavior to make and support inferences about the world. In some cases this entails acquiring

the same behaviors or mental representations held by others, in which case the range of

inferences that can be made based on a single behavior may be quite broad, and making an

37

accurate inference can depend on background knowledge (see Sperber and Wilson 1995; Boyer

1998). One explanation for faithful transmission under such circumstances is that variation in

learner inferences is decreased by *attractors*—factors such as physical affordances or innate

psychological dispositions that restrict the range of inferences made by learners (Sperber 1996;

Boyer 1998). One problem with this explanation is that attractors can only change over

historical time, at the pace of the factors of the environment, physical world, or psychology in

which they are rooted. In contrast, culture changes faster than biology (Perreault 2012), such

that genetically evolved cognitive attractors may not be able to keep pace with culturally-

evolving mental representations. This may also apply to attractors shaped by environmental

change. As a result, attractors may help to explain faithful transmission for domains of social

learning in which content varies only superficially over time and space. However, attractors are

difficult to reconcile as a mechanism for explaining the diversity of complex, locally adaptive

beliefs and technologies used by humans.

A second possibility is that help from a knowledgeable model can narrow the range of a learner's

inferences, making social learning accurate without reliance on pre-existing attractors. Overt

teaching can function this way, and psychologists studying social learning have pointed out that

models can provide subtle cues that greatly enhance the accuracy of social learning. For example,

models may use gaze to establish joint attention (Tomasello et al. 2005), or use ostensive cues to

mark some knowledge as generalizable (Csibra & Gergely 2009, 2011).

Mathematical modeling suggests that teaching—defined as behavior evolved to facilitate

learning in others—is adaptive in the context of cumulative cultural evolution, so should be

especially common in humans (Fogarty et al. 2011)., There is some experimental evidence

suggesting that humans in general facilitate cumulative cultural learning through teaching

(Dean et al. 2012), and psychologists often characterize teaching as ubiquitous across human

societies as well as unique to humans (see Csibra & Gergely 2009, 2011; Strauss et al. 2002; Kruger & Tomasello 1996; Premack & Premack 1996). However, cultural anthropologists studying childhood and learning in diverse societies claim that teaching is unique to Western cultures and absent elsewhere (Paradise & Rogoff 2009, Lancy and Grove 2010, Gaskins & Paradise 2010; see also review by Hewlett et al. 2011). At the same time, biologists claim to have documented teaching in non-human (and some non-cultural) animals including ants, meerkats, pied babblers, and several additional species (see reviews: Hoppitt et al. 2008; Thornton & Raihani 2008; Caro & Hauser 1992). Interpretation of these cases as "teaching" is still hotly debated (see Csibra 2007; reply by Thornton 2007; see also Byrne & Rapaport 2011; reply by Thornton & McAulliffe 2012).

I argue here that discrepancies in empirical claims across disciplines follow from deep-rooted theoretical differences between disciplines, leading to crucial differences in how teaching is defined. In a review of the three major approaches to the definition and study of teaching— mentalistic, culture-based, and functionalist—I show how definitions used by scholars taking these approaches lack the breadth to unify the study of teaching across human and non-human animal societies, and result in miscommunication that frustrates comparative research on the evolution of teaching. Next, I propose a new framework that differentiates among teaching types according to the adaptive problems each type solves. This framework restructures the cross-cultural and cross-species study of teaching, and puts the apparent uniqueness of human teaching behavior in evolutionary context. This includes novel implications for the study of the psychology of teaching, and clarifies problems of cooperation that may constrain the evolution of teaching. Finally, I synthesize these insights to illuminate why humans are such prolific and intensive teachers relative to other animals.

What is teaching, in theory?

Mentalistic Definitions of Teaching

Mentalistic approaches define teaching as *behavior with the intent to facilitate learning in another* (Pearson 1989, p.63). Formal definitions based on this idea state that capacities of *mind-reading* and *theory of mind* are necessary prerequisites for establishing intent to teach, from which it follows that teaching without theory of mind capacities is not possible. For example, Tomasello et al. (1993) argue that the establishment of joint attention and holding representations about the mind of the other is a necessary prerequisite to teaching. Under this view, teachers need theory of mind both to identify the need for teaching, and to figure out what it is that they ought to teach (Tomasello & Kruger 1996). According to this approach, the absence of theory of mind in non-human animals explains why only humans engage in "powerful forms of cultural learning" such as teaching (Tomasello, 1999). Tomasello & Kruger (1996, p.371) explain:

> "Teaching is a behavior in which one animal intends that another learn some skill or acquire some bit of information or knowledge that it did not have previously. … The teacher needs to behave in ways that are adapted to the skill level of the learner, for example, providing more and different kinds of instruction when the skill level is low, changing as the learner becomes more skillful, and ceasing when the skill level becomes self-sufficient. "

Tomasello and Kruger also argue that theory of mind and teaching are human universals, including formal "designed" teaching, in which adults theorize that detailed instruction is necessary in order for a child to ever reach competency, and as a result the adult creates a learning situation in which she can provide tailored teaching (Tomasello & Kruger 1996).

Ziv and Frye (2004) argue that teaching is only possible when teachers and pupils both consciously recognize (a) intentionality and (b) knowledge differences between individuals. As support for this argument, researchers cite many studies showing that children who have better success on theory of mind (ToM) tests also teach more or use more effective methods for teaching (Ziv & Frye 2004; Strauss et al. 2002; Davis-Unger & Carlson 2008), and perform better as pupils (Wellman & Lagattuta 2004). Olson and Bruner (1996) argue that without ToM there can be no ascription of ignorance, and therefore there will be no attempt to teach. According to Strauss et al. (2002), "...in order to teach, one needs to know when knowledge, beliefs, skills, etc. are missing, incomplete, or distorted, as well as how people learn" (p.1476). This goes beyond simply having the intent to teach, to having the intent to teach based upon a range of mental representations of others' mental states. This approach builds on Vygotsky's (1978) concept of the "zone of proximal development," the narrow range of learning just outside a child's developing abilities, within which he can learn, building on his present competencies through scaffolding by knowledgeable others (Guberman & Greenfield 1991; see Pelissier 1991 for review). In this view, only a teacher who identifies this proximal zone of development (through theory of mind) can understand that teaching is needed, and can then intend to teach.

Culture-based Definitions of Teaching

Culture-based definitions of teaching focus on *teaching* as it happens in formal classrooms in Western cultures. As a result, these definitions are based mostly on what may be culturally-specific features of classroom teaching. These definitions are most commonly used in anthropology and cross-cultural psychology, such that they underlie nearly all of the cross-cultural data on teaching. These data are crucial to our understanding of human variation in teaching behavior. Researchers taking this approach contrast teaching with other forms of learning outside of the Western cultural context, without explicitly defining teaching. Instead, these researchers identify teaching from a shifting set of ostensive features, including: (a) the

teacher intends to teach, (b) knowledge transmission is unidirectional (teacher to pupil), (c) pupils are passive recipients of knowledge who do not collaborate interactively with the teacher, (d) knowledge is communicated explicitly, often by verbal instruction, and (e) the activity is marked in some way and recognized as "teaching" by its participants. These criteria are not applied as a coherent checklist, but as a set of characteristics arrived at inductively via contrasts between teaching and other types of social learning. Other types of social learning that are not considered "teaching" are described as natural, simple, informal, observational, practical learning, or guided instruction (Paradise & Rogoff 2009), in contrast with "formal" learning via teaching.

To understand the culture-based definition of teaching, we must understand what it is contrasted against. In informal social learning, (a) learning takes place within an activity, where the focus is on completing a task rather than on teaching (b) learners are often expected to observe rather than participate, and (c) the responsibility for attending, learning, and ending a learning period lies with the learner rather than the model (Gaskins & Paradise 2010). In other words, learning is common through intent participation—defined as "listening-in" and "keen observation" (Rogoff et al. 2003), or through "legitimate peripheral participation," in which learning a given activity is also inextricably linked to the learner's building a sense of shared identity with other practitioners (Lave & Wenger 1991). Learners must therefore identify with their models prior to learning about an activity. In contrast, teaching is a "marked" event, such that a behavior is only teaching when participants label the activity as "teaching" *instead of* something like "line-fishing" or "weaving." In this framework, "teaching" that is embedded in another activity is informal learning, rather than formal learning or teaching:

"It is often an unmarked, fully integrated, almost invisible, part of everyday interactions. It often occurs when a caregiver or other 'teacher' has no specific intention to teach, and

42

sometimes even when the child has no specific intention to learn. For this reason, it may appear that learning happens through a kind of osmosis." (Gaskins & Paradise 2010, p. 87)

According to Paradise et al. (2009), teaching is unidirectional, or even coercive, in contrast to informal learning processes based in collaboration, guiding or showing, and learning through experience:

"In communities where children spend much of their day actually taking part in mature activities, the skills and goals of mature activities become apparent to them in a self-evident way. … In these settings there is little room for narrowly conceived instruction; those who are knowledgeable involve themselves by collaborating with the learner, by guiding and showing as they engage together in the activity. In this way they invite children to learn through their experience, with little dependence on coercion and explicit teaching." (p. 124)

In this approach, teaching is only required when learners are passive or uninterested, which a number of researchers suggest is unique to Western societies. Mead (1970, p. 12), for example, argues that in the shift toward Western ways of learning, "…the emphasis has shifted from learning to teaching, from the doing to the one who causes it to be done, from the spontaneity to coercion, from freedom to power," and that the shift toward teaching means "…the shift from the need for an individual to learn something which everyone agrees he would wish to know, to the will of some individual to teach something that it is not agreed that anyone has any desire to know."(p. 3). Elsewhere, researchers argue that informal learners are always interested, that learning happens without any need for teaching, and that learning happens without fail (Spindler & Spindler 1989; Paradise et al. 2009).

Rogoff et al. (2003) contrast informal learning with the "factory-efficiency" model of instruction, where information transfer is unilateral: "Teachers were cast as technical workers who were supposed to insert information into the children, who were seen as receptacles of knowledge or skill" (p. 181). Here, teaching is mutually exclusive with learning as "a process of transformation of participation in ongoing cultural activities" (p. 182). Instead, transformation is the result of interactive participation, not transmission (from teacher to pupil) or acquisition (by pupil, from teacher).

Lancy and Grove (2010) equate teaching with explicit or abstract verbal instruction, which they claim is rare in non-Western societies. They discuss "…the near total absence of children being taught (in the explanatory, didactic sense) by adults…" (p.145), and explain in an endnote that only three examples of this kind of teaching exist in the ethnographic literature on non-Western societies. Lancy and Grove also present several examples of guided learning that they do not consider teaching, but which would be considered teaching by the *mentalistic* definition above. For example, teaching is absent in canoe-building among the Warao, where "…there is not much verbal instruction… but the father does correct the hand of his son and does teach him how to overcome the pain in his wrist from working with the adze." (Wilbert 1976; quoted in Lancy & Grove 2010, p. 161). Weaving apprenticeships in which "…actual instruction begins in earnest when the master sits beside the boy at the loom and begins to demonstrate some simple patterns, which the novice copies…" are not classed as "teaching," because prior to instruction, pupils offset the cost of teaching through menial labor, and again there is little explicit verbal explanation (Lancy & Grove 2010, p. 160).

Functionalist Definitions of Teaching

Functionalist definitions of teaching are grounded in the observable causes and outcomes of teaching behavior, instead of the teacher's motivational state or on a particular cultural conception what it means to teach. These definitions build on a basic theoretical definition of teaching as behavior evolved to facilitate learning in others, to enable the empirically rigorous study of teaching in non-human animals for which theory-of-mind abilities and intentionality are difficult to document. Caro and Hauser (1992) first made this possible, establishing three operational criteria for behavior to qualify as teaching: (a) behavior is contingent on the presence of a naïve learner, (b) it provides no immediate benefit (or even generates a cost) for the teacher, and (c) it can be shown to facilitate learning in others.

Subsequent functionalist approaches to teaching have attempted to modify the Caro and Hauser (1992) framework. Hoppitt et al. (2008) argue that the cost criterion does not reliably distinguish between behavior that evolved for teaching versus an alternative function, so may lead to false positives. For example, food provisioning may result in offspring learning about parental food preferences, but probably evolved because it increases offspring survival rates (Hoppitt et al 2008). However, if food provisioning leads to learning by offspring at an immediate cost to parents, the Caro and Hauser (1992) definition would categorize this as teaching. Without rejecting the usefulness of the Caro and Hauser operational definition, Hoppitt et al. (2008) offer a revision of the broader theoretical definition of teaching that separates the *process* of learning from the *behavior* of teaching, such that teaching can be viewed as an accessory to other well-established social learning processes, and teaching does not have a single behavioral profile. For example, learning may happen through teaching by *tolerance of close observation*—where the adaptation of tolerance is on the part of the teacher— as compared with *close observation*, where the adaptation is on the part of the learner, who persists in observing. In this way, teaching can evolve alongside existing social learning processes, increasing learning accuracy. Teaching is conceptually distinguishable from other

45

social learning because *non-teaching* is *inadvertent*, such that the adaptation for teaching is not on the part of the demonstrator. The typology laid out by Hoppitt et al. distinguishes among teaching via local enhancement, observational conditioning, imitation, opportunity provisioning, and coaching.

Thornton and Raihani (2008) point out that the Caro and Hauser (1992) operational definition may also lead to false negatives in the study of teaching in nonhuman animals (see also Thornton & McAuliffe 2006; c.f. Byrne & Rapaport 2011). Thornton and Raihani suggest that teaching be defined instead by "key characteristics" (p.1825): "(1) it is a form of cooperative behavior with response-dependent fitness payoffs; (2) its function is to facilitate learning in others; and (3) it involves the coordinated interaction of a donor and a receiver of information." The key characteristics do not stipulate behavioral guidelines for identifying these key characteristics in the field, but do predict that teaching will be observed where its utility in increasing the pupil's learning efficiency is the highest (e.g., it most improves on other learning mechanisms).

While Thornton and Riahani (2008) and Hoppitt et al (2008) do not directly address human-specific forms of teaching, Csibra and Gergely (2009, 2011) focus on teaching as a uniquely human trait. Csibra and Gergely's definition differs from mentalistic approaches (e.g., Kruger & Tomasello 1996), in that they present teaching not as a byproduct of other human cognitive capabilities like language or theory of mind. Instead it is a driving causal force in the evolution of those capacities; the main adaptation is the motivational system that results in sharing generalizable knowledge with others, the adaptive function of which is to speed up the rate at which naïve infants gain "reliable, new, and relevant information" about the world (Gergely et al. 2007, p.140). According to Csibra and Gergely (2006) this does not necessarily require theory of mind capacities or a conscious intentionality to teach—only that the evolved psychology must

motivate some behavior that functions to facilitate learning in others. Thus the teaching

adaptation also includes behavioral markers, or ostensive cues, that highlight and mark the act

of teaching for teacher and pupil. By this definition, teaching requires: "(1) explicit

manifestation of generalizable knowledge by an individual (the 'teacher'), and (2) interpretation

of this manifestation in terms of knowledge content by another individual ('the learner')"

(Csibra & Gergely 2006, p.5). Notably, it does not require that teachers or pupils are

consciously aware of these processes—unlike the mentalistic or culture-based definitions. By

this definition, the teaching adaptation is both a special learning mechanism—because it

requires an adaptation by both parties—and a special type of communication—because it

evolved specifically to convey generalizable, abstract content (e.g., tigers are always dangerous)

as opposed to fleeting, concrete content about the current state of the world (e.g., there is a tiger

behind you). As a result, this definition is narrower than other functionalist definitions, because

it characterizes teaching as an adaptation to facilitate learning in others, for a particular type of

content (generalizable knowledge) and kind of learning (knowledge transfer).

Limitations of existing definitions of teaching

A useful definition of teaching should be both specific and flexible, able to organize extant data

on teaching, and teaching-like behavior, within a single framework, thereby promoting

comparisons across species and cultures. Such comparisons can reveal ancestral versus derived

traits as well as generate explanations for the observed distributions of teaching behaviors.

Definitions lacking these properties are barriers to understanding the form, function and

evolutionary history of teaching.

Mentalistic definitions are limited in several ways. First, by foregrounding the intent to teach,

mentalistic definitions exclude from comparison a number of teaching-like behaviors that

plausibly serve the same adaptive function as behaviors that they do classify as "teaching."

Species that do not demonstrate human-like theory of mind capabilities are, by definition, excluded from this category—even when facilitating learning in others would be adaptive, and they perform behaviors that do so. For example, according to mentalistic definitions, chimpanzees that entice infants to walk are not teaching, but humans are teaching when they entice infants to walk (see Tomasello et al. 2005). Second, even if ToM capabilities are granted to a particular non-human species, intent-to-teach is still comparably easy to establish for humans but near-impossible to establish in other animals. This practical problem severely handicaps comparative work. Finally, mentally representing the intent to teach has no adaptive value by itself; only the teaching behavior has adaptive value. It follows that as long as pupils act as if they expect to receive relevant information, and learn it effectively, an interaction can fulfill the adaptive function of teaching. Such a response does not necessitate theory of mind *a priori*, if there are alternative psychological mechanisms (see section on *teaching as cooperation* for some possibilities). This is not merely a hypothetical—non-human animals change their behavior in response to communicative displays like alarm or food calls quite reliably and without extensive theory of mind capabilities (as far as scientists can tell), so it is reasonable to think they might do so in response to teaching behavior. Note that this does not mean that researchers should stop studying intentional teaching behavior—only that the role of intentions in the evolution and adaptiveness of teaching ought to be viewed as an unsolved question, not as an answer.

Culture-based approaches to teaching also fail to accommodate cross-species and cross-cultural comparisons. In the culture-based approach, teaching is characterized as formal, decontextualized, and based on verbal explanation. Strauss (1984) argues that the formal/informal dichotomy is ethnocentric, because it is based more on cultural biases favoring Western-style formal schooling than on a real cognitive divide. This is not a new critique (see for example Curran 1980; also Rogoff 1981), but it has not been incorporated into much of the

more recent work examining the cross-cultural prevalence of teaching. In addition, the use of implicit and sometimes inconsistent definitions of teaching can lead to implausible claims about the rarity of teaching. For example, Lancy and Grove (2010) claim that teaching in general is rare to absent in non-Western societies (p. 160). Western societies may have culturally derived forms of teaching—for instance, the factory-industry model of teaching in which pupils are empty vessels to be filled with official knowledge (see Paradise & Rogoff 2009). However, focusing on the dichotomy between "teaching," defined to be precisely the same as Western teaching, and "not teaching," defined as anything else, is not useful in efforts to understand how it is that behavior evolves to facilitate learning in others, because it eliminates any possibility for comparative work across species and cultures.

Functionalist definitions of teaching, though focused primarily on evolutionary history and the adaptive consequences of teaching, also do not explain the full range of behaviors that evolved to facilitate learning in others, especially where humans are concerned. Typically, teaching as observed in humans is not considered in shaping functionalist frameworks, so that at least some human teaching seems to remain uncategorized and unexplained by functionalist definitions. Specifically, the language- and theory of mind laden types of teaching that are the focus of the culture-based and mentalistic approaches are discussed but not categorized within the frameworks proposed by Caro and Hauser (1992), or Hoppitt et al. (2008). Instead of incorporating this kind of teaching into their explanatory frameworks, functionalist treatments often accept the assertion made through the mentalistic approach (e.g., Tomasello et al. 2005)— that humans have species-typical, unique teaching capabilities based in theory of mind and intentionality, that represent a gap between human and non-human animal cognition. For example, Byrne and Rapaport (2011) state that all human teachers across cultures can identify another's lack of knowledge and target their teaching toward specific knowledge gaps. Thornton & McAuliffe (2012, p.e8) accept that humans share universal motivations and capacities for

teaching as described in Tomasello et al. (2005), though they note it is not the only kind of teaching humans do. Functionalist treatments also state that teaching is a human universal, without citing empirical evidence. For example, Thornton and McAuliffe state that "[t]eaching is ubiquitous in human societies" (2006, p.227), and elsewhere that "[i]ndeed, all human children must be taught" (2012, p.e8). These researchers use a broad functionalist definition of teaching, so their claims may be empirically correct, but there is no systematic empirical work documenting that teaching happens across all human societies, since nearly all of the cross-cultural data to date comes from the culture-based approach. (For some evidence that teaching characterized more broadly does occur outside Western societies in at least some cases, see Kline *in prep,* Chapter 3; Kline et al. 2013; Hewlett et al. 2011).

Despite acknowledging exceptional levels of teaching in humans, researchers using functionalist definitions often neglect to explain the apparently unique qualities of human teaching within the same framework they use to study teaching in other species. This is akin to studying kin selection but leaving out eusocial insects. If humans are abnormally prolific and sophisticated teachers in comparison to other animals, it is all the more important that any framework for understanding the evolution of teaching should be tested against the human case. In fact, there is little scientific basis for claims about the preponderance of teaching in humans—it is not possible to establish a direct comparison across species without a robust comparative definition. The one functionalist definition that does seek to explain teaching in humans defines teaching as a universal and uniquely human adaptation (Csibra & Gergely 2009; 2011). This definition excludes all the existing variation in other animal species, and again assumes ubiquity of teaching in non-Western societies without much ethnographic evidence for support. It should be noted, however, that the lack of ethnographic evidence may be the result of culture-based approaches overlooking variation that is relevant for a functionalist definition.

A Taxonomy of Teaching Adaptations

The taxonomy that I propose differs from existing ones in several important ways. First, unlike mentalistic and culture-based definitions of teaching, this taxonomy does not focus on the line between "teaching" versus "not teaching." Instead, it defines teaching as *behavior that evolved to facilitate learning in others*, and focuses on a number of distinct teaching types. Second, this framework differs from previous functional taxonomies (e.g., Hoppitt et al. 2008) in that its categories are derived *a priori* from theoretical adaptive problems that are inherent in social learning, rather than inductively from preexisting categories of social learning mechanisms. As a result, this taxonomy covers the full range of possible conditions in which teaching could evolve, and incorporates all known teaching mechanisms in humans and other animals into a single theoretical framework. Finally, by focusing on the specific adaptive function of particular teaching types, the framework is a tool tailored both for identifying contexts in which teaching is expected to evolve, and for creating an ethogram of what each teaching type may look like "in the wild."

This taxonomy aims to cover the full space of learning problems that could be solved by teaching, and to account for all known types of teaching, across cultures and across species. The specific examples below are based on long-term fieldwork in Fiji, and should be regarded as illustrative but not defining. For ethnographic background, see Kline et al. (2013). Since more than one teaching type can solve a given learning problem, the taxonomy is meant to be modifiable and expandable should additional teaching types be observed in the lab or field. In addition, it should be noted that social learning problems may overlap in real life, so that more than one teaching type might happen on a given occasion.

For all the teaching types below, it will be important in practice to distinguish between actors' baseline behaviors versus their behavior during an episode of teaching. Exactly how these

behavioral changes are measured will vary by activity and by species (and in humans, perhaps by culture), so the possibilities are not laid out in detail below. (For an ethogram of behavioral features of teaching in humans, see Kline [*in prep,* Chapter 3]). In some cases, this may not be enough to rule out alternate explanations. Since teaching in general is defined as behavior that evolved to facilitate learning in others, another way of distinguishing teaching from alternate explanations is to demonstrate that the benefits to the teacher are indirect and derived through improved pupil learning. In contrast, documenting that there are direct benefits to the teacher would suggest that an alternative explanation is likely, though it would not necessarily rule out teaching entirely.

Teaching types

Teaching potentially solves a number of different adaptive problems that arise in social learning. In order to learn, pupils must (a) attend to, and (b) have access to, relevant information, defined as novel information which is useful and/or in some way connected to the pupil's prior knowledge (Sperber & Wilson 1995). This includes information that is accessed through experience, observation, or direct communication. When attention or relevant information (or both) would otherwise be lacking, teaching may make learning possible, more efficient, or more accurate.

 Teaching by social tolerance.

Adaptive problem: a pupil attends to relevant stimuli, but does not have the knowledge or skill to undertake some task because it requires observing a conspecific's behavior. The learning problem could be solved through *teaching by social tolerance*—defined as teaching in which the teacher does not stop the pupil's close and intrusive observation. For example, in Fiji, women who are cooking often tolerate close observation by children—even to the degree of pausing their own work, as children stick their hands into bowls or grab and

manipulate mixing tools that are crucial to the women's food preparation tasks. This kind of teaching by social tolerance can be distinguished from the social tolerance that evolved for other functions, in that the degree of tolerance toward pupils is greater than species-typical tolerance toward other conspecifics. It is worth noting here that many species are highly tolerant of young, in general (presumably because they impose little threat or cost to adults). Where this is the case, evidence for teaching by social tolerance might include heightened social tolerance in situations, or during activities, when the potential gains in learning for young are especially high.

Teaching by opportunity provisioning.

Adaptive problem: a pupil attends to relevant stimuli, but lacks the opportunity to undertake some task because it is too difficult or dangerous to explore individually. When this is true, *teaching by opportunity provisioning* may solve the learning problem. Teaching by opportunity provisioning occurs when a teacher creates opportunities for the pupil to practice—opportunities for individual learning—that would otherwise not exist. For example, adults in Fiji sometimes make day-to-day tasks easier so that children can participate, as when one four-year-old boy who apparently knew (in theory) how to fetch water from a well using a bucket and rope could only do so with the help of his uncle's physical strength. (The task was far slower and much more water was spilled than if the uncle had completed the task alone). Other instances of teaching by opportunity provisioning may or may not include a scaffolding component, in which the teacher scales up the difficulty of the learning opportunities with the maturity or skill of the pupil. This is similar to Caro and Hauser's (1992) definition of *opportunity teaching* as when a teacher puts a pupil in a situation that makes learning likely.

Teaching by stimulus or local enhancement.

Adaptive problem: a learner may not attend to a relevant stimulus, though it is accessible. This category may also include cases where the pupil is afraid of, or otherwise repelled by, a learning-relevant stimulus. When individual learning, once triggered, might suffice for producing adaptive behavior on the part of the pupil, *teaching by stimulus or local enhancement* might evolve to facilitate initial bouts of individual learning. Teaching by stimulus or local enhancement is defined as a teaching type in which the teacher stimulates the pupil's interest in a stimulus or location, potentially leading to a discovery or skill development following the pupil's individual learning. This may occur with varying levels of effort by the teacher and resistance by the pupil. As in many other societies(Bryant & Barrett 2007), Fijian adults often make use of both pointing and *motherese* (infant-directed speech) to manipulate a child's attention toward relevant stimuli. The target of attention can include anything from a relative walking across the village, to a breaching dolphin, or even an otherwise unremarkable object like a palm leaf or a hinged house door.

Teaching by evaluative feedback.

Adaptive problem: a pupil may not attend to existing feedback or possible consequences regarding their behavior, though they have access to that information. That is, the pupil either over- or under- uses a behavior, and does not have cognitive access to information about the resulting outcome. Teaching by evaluative feedback can solve this adaptive problem, when a teacher provides positive or negative reinforcement conditioned on the pupil's behavior. This may be particularly common for opaque social rules or costly outcomes. For example, Fijian adults and even older children teach young children that touching another person's head is *tabu* ("taboo", or forbidden), by scolding children whenever they happen to do so. There are many opportunities for children to make this "mistake," because a toddling child is often at head-height with adults who are sitting cross-

54

legged on the floor as is typical in Fiji. Elsewhere, teaching by evaluative feedback is called

coaching, training, or encouragement/ discouragement (e.g., Caro & Hauser 1992). This

teaching type may include the extremes—removing a behavior from the pupil's repertoire

altogether, or making it omnipresent—as well as reinforcement that depends on the

particulars of the situation.

Direct active teaching.

Adaptive problem: a pupil lacks both attention and access to a relevant stimulus or

information. As a result, the pupil cannot gain this information through individual learning

mechanisms, and has no way to solve the "frame problem." This may arise either in an

evolutionarily novel situation, when no individual learning mechanisms exist to interpret the

fitness-relevant components of that situation, or when a pupil simply lacks background

knowledge. As a result, the frame problem may shift with pupils' changing knowledge levels.

The frame problem may be solved by *direct active teaching*. This is similar to what Gergely

and Csibra (2009; 2011) define as teaching, but is not necessarily limited to humans, and

does not require ostensive cues (at least by definition). *Direct active teaching* is

characterized by (a) manifestation of *relevant* information by the teacher to the pupil and

(b) interpretation of this manifestation in terms of knowledge content by the pupil. It differs

from other teaching adaptations in that it requires some shared background knowledge as

well as a means of direct communication, so that the teacher can identify and communicate

the relevant information to the pupil. In Fiji, for example, direct active teaching might

include a father's verbal explanation to his eight year-old daughter, complete with pointing

and illustrative hand movements, of how to extract a turtle intestine from the rest of the

carcass. It could also include a non-verbal demonstration, punctuated with exaggerated

movements, by an expert weaver to a novice weaver. Alternatively, it might include an

exclusively verbal description of where turtles lay their eggs, what butterflies eat, and where

55

dolphins sleep, as one mother replied to her four year-old son's questions about wild animals.

Note that while direct active teaching may include all "teaching" as categorized by the culture-based definitions, it is a much broader definition. Direct active teaching does not use the same criteria for identifying teaching as the culture-based definitions. In practical applications it would subsume the culture-based definition, but dispenses with the requirements of teacher intentionality, unidirectional transmission, pupil passivity, and labeling of the activity as "teaching" by the teacher and pupil. The culture-based definition and this definition of direct active teaching share in common the requirement for "direct" or "explicit" communication of information. However, they differ slightly even here, in that direct communication is not exclusively verbal under the definition of direct active teaching.

How this framework improves on previous definitions

Much of the present debate over the form and distribution of teaching behaviors results from different schools of researchers focusing on *different teaching adaptations* as if they represent the entire category of "teaching." The more fine-grained approach outlined here has the potential to end these debates by integrating the entire range of documented variation in teaching adaptations. Because this framework covers all of the informational contexts in which teaching might evolve, it provides a comprehensive structure by which to categorize known (and future) teaching behaviors.

This framework categorizes teaching types according to theoretically significant learning problems, rather than by behavioral profile or based on known mechanisms of social learning. These learning problems are not content-specific, but instead describe contexts in which teaching could facilitate learning. This approach allows for straightforward empirical

applications across species and cultures, since learning problems can be analyzed in terms of these informational contexts rather than according to domains of content to be learned. This approach does not prevent researchers from continuing to focus on subsets of teaching behaviors. Instead, it clarifies the appropriate interpretation of research on particular culture-specific or species-specific forms of teaching, and facilitates comparisons across teaching types Below, I demonstrate the utility of this framework by using it to reinterpret the existing data on the prevalence of teaching in humans and other animals, and to reexamine what evolutionary theory can tell us about why humans are such prolific and intensive teachers.

Reconsidering the Prevalence of Teaching

Broad claims and limited evidence

The prevalence of teaching in humans and other animals is a contentious issue. Some researchers make sweeping statements about the omnipresence of teaching cross-culturally, contrasting animal societies with "human societies, where teaching is common" (Thornton & Raihani 2010, p. 297) or claiming that "…it is (almost) incontrovertible that teaching is ubiquitous in human beings, which means that, with few exceptions, every person in every society has taught and has been taught by others" (Strauss et al. 2002, p. 1476). In contrast, others claim teaching is uniquely Western (Paradise & Rogoff 2009; Lancy & Grove 2010, Gaskins & Paradise 2010; for review, see Hewlett et al. (2011). In reality, the story may be more complicated. For example, my own field work in Fiji suggests that not only is teaching common there, contrary to previous claims (Hocart 1929, Ritchie & Ritchie 1979, Lancy & Grove 2010), but also that the prevalence of teaching varies adaptively across domains and life stage (see Kline et al. 2013). This suggests that a study including only some age groups or domains might seem to document an absence of teaching.

Based on mentalistic or culture-based definitions of teaching, it seems obvious that animals lacking in the ability to consciously represent others' mental states cannot teach. On the other hand, animal behaviorists identify a number of species that display what they call teaching, based on observable behavior. Unlike much of the anthropological field research on teaching in non-Western human populations, these studies typically adhere to strict criteria enumerated in operational definitions (e.g., Caro & Hauser 1992), which may cause false negatives in the study of teaching (Thornton & Raihani 2010). Even so, established examples of teaching in non-human animals are critiqued on the grounds that they "…do not seem to be particularly good examples of the activity that, as humans, we would call 'teaching,' " and might instead be labeled "scaffolding," or "charitable information donation" (Csibra 2007, p. 96). The problem with these and other claims about teaching-in-general is that each is based on one of the narrow definitions of teaching, and disagreements often result when researchers have not settled on the same one. The present taxonomy illuminates the distribution of different teaching behaviors across species and societies, and thereby facilitates comparative studies of their phylogenetic histories and adaptive functions.

Teaching in Humans

In what follows I review evidence for each type of teaching distinguished in the present framework. This is not meant to be a comprehensive review of teaching in humans. Instead, I have focused mostly on the examples used throughout the literature on teaching in humans, drawing mostly from researchers using *mentalistic* or *culture-based* definitions of teaching. In many cases, these same ethnographic examples have been used as examples of "non-teaching" under *culture-based* definitions. Ethnographers often describe these behaviors in terms of teachers' mental states, including teachers' expected outcomes. These mental states are sometimes included in descriptions below. However, in this framework, mental states do not

function to distinguish between teaching types, so these details should be regarded only as contextual information, not as diagnostic features of teaching behavior.

Teaching by social tolerance. In humans, it is common for children to learn by observation and participation (Rogoff et al. 2003; Paradise & Rogoff 2009; Lancy & Grove 2010; Lave & Wenger 1991). Where knowledgeable actors tolerate interference or some other cost in order to permit learners to observe or participate, learning-by-observation can be classified as a low-effort form of teaching. This form of learning is common in Fijian villages where children's poking and prodding laundry to be washed, or fish to be cleaned, is not stopped by the adult even though it slows down the adults' work *(personal observation).* During early stages of a human apprenticeship, targeted tolerance of observation may be the predominant method of teaching (see Coy 1989). According to Hogbin (1970, p 143) explains that in Wogeo, New Guinea: "Children are also encouraged to work side by side with their parents even when their efforts are likely to be a hindrance," and children's interference is tolerated during canoe making, with the expectation that they will learn and be able to contribute in the future.

Teaching by opportunity provisioning. In humans, it is common for adults to assign "chores" to children in many different cultural contexts (Lancy 2008). These chores are often assigned according to the child's physical capabilities (Bliege-Bird & Bird 2002; Bird & Bliege-Bird 2005; Kline et al. 2013), and are sometimes explained solely in terms of their role in the economy of the household, which is one possible explanation for their existence (Lancy 2008). However, chores can also function to provide learning opportunities for a large variety of tasks that adult humans must learn to perform, so may sometimes constitute teaching by opportunity provisioning—especially where they are fused with play (see Bock 2002 for a life history treatment that analyzes these alternative explanations as tradeoffs). Minimally, opportunity provisioning may simply involve providing access to a stimulus that is otherwise unavailable to

59

children. In a description of music lessons in Bali, McPhee (1969) explains that a music teacher simply plays music for his students without modification, and expects that the students will learn as a result of their unique access to his playing. This is opportunity provisioning (rather than teaching by enhancement or social tolerance) because the music is produced only for the students, creating an otherwise nonexistent opportunity for observation. Some storytelling can provide opportunities for naïve individuals to learn from second-hand experience, for example inexperienced hunters may learn a great deal from the details of stories (MacDonald 2007). When these stories are preferentially provided to naïve learners, they can be considered teaching. In a study of Inuit childhood, Briggs (1998) reports that adults may create dramatic situations or social dilemmas to challenge children, causing them to learn important lessons about social conduct and emotional regulation through these adult-manufactured experiences. Quizzing or question-and-answer sessions may also provide an opportunity for learning to make high-risk decisions without actual danger. Among the Fort Norman Slave, fathers may verbally quiz their sons about travel paths according to hypothetical ice conditions—if boys answer incorrectly, they are "mildly chastised and urged to reconsider" (Basso 1972, p.40).

Teaching by stimulus or local enhancement. Human adults point, vocalize, gaze, at or touch objects in the presence of infants, sometimes using stereotyped speech (see Brand et al. 2002) and/or gesture (see Fernald & Mazzie, 1991). These behaviors often persist until the infant engages with the stimulus. There is some evidence that the degree to which different modalities are used to manipulate children's attention varies cross-culturally (Akhtar & Gernsbacher, 2008) and that the overall frequency of stimulus enhancement also differs across populations, along with socio-cultural models of proper childcare (Lancy 2007). Nevertheless, prosodic features of infant-directed speech may be a human universal (Bryant & Barrett 2007). Among the Warao of South America, canoe makers may require boys to be present when they plan to build boats, with the assumption that they will learn through exposure without any instruction

60

(Wilbert 1976). This differs from opportunity provisioning in that the canoe-makers must make the boats whether or not the boys observe them. In Native North American societies, it is common for adults to expect children to learn by seeing (Cazden & John 1971), and adults may specifically direct their attention by pointing or otherwise focusing children's attention, and sometimes naming stimuli (Lee 1967).

Teaching by evaluative feedback. Human adults often encourage or discourage a broad range of behaviors in children (Rogoff et al. 2003; Paradise et al. 2009; Gaskins & Paradise 2010; Lancy & Grove 2010). Adults might slap a child's hand as he tries to touch a fire, poisonous animal, or other dangerous object. In cultures where "early" walking is undesirable, adults may also physically punish a child who attempts to walk (e.g., among the Beng; Gottlieb 2004). In Nepal, adults give explicit verbal feedback, or may shame children who are considered old enough to know better, in a variety of domains (Levy 1996). Shaming through verbal teasing is common across cultures (see Lancy 2012, p.87; Lancy & Grove 2010, p.157; Rogoff et al. 2003). In Javanese society, adults tell stories about children who failed to learn and grew up to be useless to society, to motivate children to learn their chores (Geertz 1961).

Direct active teaching may be common in humans in a range of behavioral domains including food selection and preparation, hygiene, mating behaviors, religious ritual, abstract concepts (like mathematics), and word learning. Further, many populations of humans have formal or semi-formal institutions to promote direct active instruction, including Western-style schools, bush-schools, apprenticeships, or tutor-pupil privileged relationships. Among the Wogeo of New Guinea, orphans are considered to be disadvantaged because they must learn despite a lack of "deliberate instruction" that most children can expect from their parents (Hogbin 1970, p. 143). Yurok-Karok adults provide "special instruction" for children who seem interested in weaving (Pettitt 1946, p.46). Pettitt suggests that this is because learning by observation alone

would not be sufficient. Social norms and kinship terms of address are often explicitly taught through verbal instruction and labeling of relatives (see Lancy & Grove 2010, p. 150). In New Guinea, Wogeo men verbally critique children's hand-made toy boats, offering theories and solutions for the boats' poor performance, which children then implement and retest (Hogbin 1970).

Direct active teaching is not always verbal. Among the Warao of South America, a father might physically reposition his son's wrist as the son learns to make a canoe, in order to prevent wrist pain (Wilbert 1976). Similarly, a Wogeo man in New Guinea might reposition his son's hands on a digging sick, while also explaining that it prevents back pain (Hogbin 1970). Instruction may also consist of demonstration without extensive verbal explanation, as when Dioula master weavers sit side by side with their apprentices in order to show them simple patterns, after years of more menial and basic tasks (Tanon 1994). Demonstration can also be combined with hands-on practice, as when a Tlingit mother shows her daughter how to weave, then takes turns with her daughter, weaving alternate rows on the same basket (Laguna 1965). This method is also common in Fiji, where one woman reported that this is how she learned to weave from her mother, and how she taught her adopted daughters. Her own mother agreed this is how she taught all of her daughters, and said that *her* mother taught her the same way–covering a total of four generations *(personal observation)*. As Navajo girls learn to weave, they may also be shown rather than told (Reichard 1934), and any verbal or nonverbal feedback is likely to be immediately relevant rather than abstract.

Teaching in Other Animals

As with the review of teaching in humans, the review of teaching in non-human animals is not meant to be exhaustive, so that some possible examples of teaching may not be included here. In addition, it should be noted that the examples offered below include quantitative studies, some

of which adhere to Caro and Hauser's (1992) criteria for documenting teaching, as well as

qualitative observations and anecdotal evidence.

Teaching by social tolerance can also be described as tolerance of information scrounging.

High-tolerance behavior like this has been documented in several non-human primate species.

In vervets, yellow baboons, mantled howlers, and capuchins (see Rapaport & Ruiz-Miranda

2002), adults are highly tolerant of close observation and even intrusive touching by immatures.

Unlike food scrounging among adults, social tolerance of interference by immatures cannot be

explained by the potential cost of an ensuing fight (Blurton-Jones 1987), because of the relative

weakness and small size of immatures as compared to the adults they are observing—such that

the costs of exclusion would predict the opposite pattern (exclude immatures, tolerate more

formidable adults) from that predicted by teaching by social tolerance.

Teaching by opportunity provisioning has also been documented in the wild, especially among

predators. Wild meerkats hunt and disable prey (Ewer 1969), then present it to meerkat pups.

Adult meerkats disable the prey to different degrees depending on the developmental stage of

the pups, as gauged by the pups' food calls. The pups then finish processing the prey and so

develop the skills to manage the prey without being exposed to the risk of injury, for instance

from scorpion stings (Thornton & McAuliffe 2006). Domestic cat mothers also capture and

recapture prey, allowing their offspring to interact with it (Ewer 1969; Caro 1980), as do river

otters (Liers 1951), cheetahs (Kruuk & Turner 1967), and tigers (Schaller 1967). Orcas that are

beached along with their offspring sometimes flip live prey toward their offspring, and may do

the same in the ocean (Lopez & Lopez 1985).

Teaching by stimulus or local enhancement has been described in animal skill-acquisition and

especially foraging, across species. In river otters, some mothers drag their offspring into the

water until they learn to swim (Liers 1951), and a similar behavior has been observed in the California sea lion (see Caro & Hauser 1992). Long-tailed macaque mothers have been documented to intensify and exaggerate tool use (in this case, using human hair as dental floss) in the presence of their infants (Masataka 2009). Golden lion tamarin adults locate hidden prey and then emit a food-transfer call (typically used for transferring already-obtained food items), leaving the young to extract the prey on their own before eating it (Rapaport & Ruiz-Miranda 2002). Domestic hens increase pecking intensity towards palatable food, when their chicks appear to be eating unpalatable food (Nicol & Pope 1996). Tandem-running ants that have located a food source will lead naïve ants to that food source and are responsive to feedback from the naïve ants (Franks & Richardson 2006; Richardson et al. 2007). Atlantic spotted dolphins chase prey longer and make more referential body-orienting movements in the direction of prey when calves are present (Bender et al. 2009). Orcas accompany and may lead offspring toward hunting grounds, and charge alongside their offspring in beaching attempts. The adult does not actually beach in these cases, but the offspring do (Lopez & Lopez 1985). In some of these foraging examples, it would most likely be more efficient for adults to kill the prey and provision offspring directly—which suggests that the most plausible interpretation of these behaviors is to facilitate learning in offspring.

Teaching by evaluative feedback has been observed across a number of non-human animal taxa. Female river otters may nip at the noses of their young if they run ahead of her, rather than following behind (Liers 1951). In chimpanzees, mothers or older siblings may take unfamiliar food away from an infant or juvenile, restricting its diet, and captive macaques may prevent offspring from exploring novel stimuli, or stimuli known to be dangerous (see Caro & Hauser 1992). However, it is not clear how widespread these food-limiting behaviors are among non-human primates (see Hikami 1991; Fairbanks 1975). Primate mothers of many species encourage their offspring to walk by setting them down and then looking/calling for them to join

(e.g. chimps, gorillas, rhesus macaques, free-living yellow baboons, spider monkeys; see Caro & Hauser 1992; see also Maestripieri 1995, 1996). Adult pied babblers emit a purr-call while provisioning nestlings such that nestlings learn to associate the call with food (Raihani & Ridley 2008), and the purr-call is later used to encourage fledglings to approach adults in both food- and non-food circumstances (Raihani & Ridley 2007). An alternative explanation for at least some of these examples is that giving feedback evolved to alter behavior in real time—for example to lower the costs of parental care by eliciting independent locomotion—rather than to facilitate learning. For this teaching type, it may often be necessary to distinguish between direct and indirect benefits to the potential teacher in order to distinguish between teaching and other explanations for behavior.

Direct active teaching. There are no observed examples of direct active teaching in non-human animals, with the exception of Boesch's (1991) anecdotal account of two potential instances of "demonstration" of nut-cracking techniques by chimpanzee mothers. However, the lack of replication of this observation encourages caution in generalizing from it.

Psychologies of teaching

The present taxonomy of learning problems paired with specific adaptations for teaching generates novel hypotheses about the landscape of possible teaching psychologies. Specifically, this framework suggests that a suite of psychological mechanisms could underlie each of the different teaching types, and that for at least some teaching behaviors, more than one evolved psychological mechanism is possible. In addition, it suggests that pupil and teacher psychologies should be considered separate adaptations that may have coevolved under selection pressures for particular teaching types.

An overarching problem for teachers and pupils alike is to limit teaching to information that is useful for the pupil's learning process. There are three categories of information to consider in this context (and in communication more broadly): prior information which the recipient already knows, novel information which has no utility, and novel information which is useful and/or in some way connected to the pupil's prior knowledge (Sperber & Wilson 1995). The latter type is useful in the learning process, and considered *relevant* information (Sperber & Wilson 1995), because it is novel and can be interpreted by the recipient, who may use it to generate new inferences. By definition, only relevant information will promote pupil learning.

5.1 Pupil psychology

For teaching to have any adaptive consequences, the pupil's psychology must be sensitive to relevant information in the context of teaching. For teaching by social tolerance and by opportunity provisioning, pupils are already motivated to learn about relevant stimuli, and sensitive to relevant information (in both cases, the learning problem is access rather than interest). For these teaching types, teacher behaviors evolved to take advantage of preexisting behaviors or motivations in pupils, and pupil behaviors and motivations would need little to no modification for teaching to be effective.

In teaching by local enhancement and by evaluative feedback, pupils must be sensitive to teacher cues and feedback that indicate relevant information. This is not a teaching-specific psychological adaptation in pupils, because the same kinds of cues are germane to other forms of social behavior. For example, social learners may already attend to others' demonstrated interest and to positive or negative social reinforcement. In all of these teaching types, the adaptation is on the part of the teacher, who displays these behaviors preferentially toward naïve learners, thereby facilitating learning.

In contrast, *direct active teaching* is characterized by manifestation of relevant information by the teacher to the pupil, as well as the pupil's interpretation of that information as generalizable. Because direct active teaching is a solution to the frame problem, it is expected to evolve only when pupils have very limited or very costly alternative individual or social learning mechanisms available. As a result, in direct active teaching, the pupil's only indication that information is relevant comes from the teacher.

There are a number of hypothetical psychologies that would make this possible. First, in mentalistic approaches to teaching, pupils must theorize about the teacher's motivations and recognize that a teacher *intends* to teach. In this model of the pupil's psychology, a pupil who recognizes teaching may be receptive, or may reject a teacher's influence (see section on *skeptical pupils*). This model also predicts that direct active teaching will be limited to species with theory of mind capacities, since a pupil's receptiveness to direct active teaching depends upon recognizing the teacher's intent.

Alternatively, teachers and pupils may have evolved a system of communication to reliably indicate the exchange of relevant, generalizable information. Csibra and Gergely (2006) argue that this is a defining feature of teaching: when teachers mark their behavior using ostensive cues (e.g., eye gaze, use of pupil's name, soliciting joint attention, etc.), pupils act as if they expect to receive relevant information that *should be learned*. This does not necessarily require that teachers or pupils consciously theorize about the contents of the other's mind. It only requires that ostensive cues reliably result in learning receptivity on the part of the pupil. This is not a novel style of reasoning that applies only to teaching. For example, animals may respond to behavioral solicitations of play or grooming, without theorizing about the mind of the conspecific making the request. This suggests that direct active teaching need not be restricted

to species with theory of mind capabilities—at least not from the perspective of the evolved psychology of the pupil.

Teacher psychology

For most teaching types, teachers can build upon existing pupil behaviors and motivations to shape pupil learning. However, teachers must still have psychological adaptations that make teaching more likely in situations where it will be adaptive. All else equal, they must provide teaching when it is adaptive—and that means providing information when it is *relevant*.

Again, theory of mind is one solution to the problem of relevance. For all teaching types, teachers could use theory of mind to assess what pupils know or do not know, and could subsequently provide information that is useful given the pupil's mental state. Theory of mind capacities may be necessary when the teacher's explicit proximate goal is to produce conceptual change in a pupil—shaping the pupil's understanding to match a predetermined concept as known by the teacher (e.g., Carey 2000). In other cases, the need for theory of mind capacities is less clear. For example, theorizing about the pupil's mind may only be necessary when there is expected to be great heterogeneity in pupils' knowledge states, and when their knowledge status is not tied to any cues that would be reliably present (over an evolutionary time span).

In cases when pupils' learning needs are reliably tied to cues of age or maturity, teachers do not need to assess a particular pupil's mental state in order to provide relevant information. Instead, teachers may simply provide information that is typically relevant to pupils at a particular life stage or in a given situation. For instance, human adults in many societies interact with pre-verbal infants through modified infant-directed language (see review by Snow 1995) and gesture (Iverson et al. 1999). The proximate mechanism for this is not necessarily that adults theorize about the contents of infants' minds and strategically expose them to intensified emotional

expression and to age-relevant vocabulary. Instead, it may be that the adult's own emotional

reaction to young children, or their desire to see babies react, directly motivates behaviors like

motherese or "baby talk," and other infant-directed behaviors. At the ultimate or evolutionary

level, the motivational system matters very little, so long as children are exposed to relevant

stimuli. The same sort of mechanism is evidently at work in meerkats. Adult meerkats provide

pups with dangerous prey (scorpions), and depend primarily on vocal cues of immaturity to

determine how much to disable the prey before provisioning (Thornton & McAuliffe 2006).

Alternatively, teachers may provide relevant knowledge based on pupil-specific cues that depend

on a meta-cognitive understanding of a behavior or task. Meta-representation for the purposes

of teaching means that the teacher holds representations of her own knowledge, which is itself

in the form of representations (Sperber 2000). In common parlance, this is "knowing about" or

having conscious knowledge of a task. Csibra & Gergely (2006) argue that teachers must meta-

represent their own knowledge, analyze it, and selectively provide information to pupils that is

relevant to the task at hand and adjusted to the learner's performance. As long as teachers meta-

represent their own knowledge, they could use cues from pupil behavior or from the context to

deduce which bits of their knowledge are relevant, without employing theory of mind (Csibra &

Gergely 2009, 2011). When relevance is based on behavioral (as opposed to mental) assessment,

the teacher does not distinguish between what the pupil *knows* and what she *does*, and only

provides feedback on aspects of the behavioral performance of a task.

There is some evidence for a role for metacognition in teaching. Conscious access to one's own

knowledge may play a minor role language-learning (Karmiloff-Smith 1985) and a more

important role in what appears to be metacognition *of* metacognitive instruction—instruction on

learning how to think about one's own metacognition in order to learn more effectively (Adams

et al. 1998; Gourgey 1998). There is also evidence that metacognitive awareness of teaching may make children more sensitive and sophisticated teachers (Davis-Unger & Carlson 2008).

Intuitively, it may seem far easier to theorize about another's mind than to evaluate his task performance through metacognition and behavior-matching. However, it is important to realize that while ToM may be an "easy" task for humans, it is not necessarily the case for other animals. Both theory of mind and metacognition are hypothetically feasible solutions for the problem of providing relevant information from the perspective of the teacher. Alternatively, teaching behaviors that are produced reliably in response to a cue (of pupil age or maturity, for example) may not require either theory of mind or metacognition. This suggests that predictions about the role and prevalence of teaching across species that are based only on species differences in theory of mind or metacognition may not be robust. It may require more than considering cognitive constraints to explain why some teaching types are more common than others, some species are more avid teachers than others, or why direct active teaching seems to be so rare. Another factor to consider is the cooperative nature of teaching.

Teaching as cooperation

Teaching is a cooperative behavior, as it benefits both the pupil and teacher through the pupil's improved social learning outcomes. Models by Fogarty et al. (2011) suggest that teaching (in general) should be exceedingly rare, and limited only to information that pupils cannot learn by other social or individual learning mechanisms, and to information that can be learned from relatives. This section goes beyond Fogarty et al.'s (2011) analysis to examine the costs and benefits of specific teaching types, and to consider two cooperative problems may act as barriers to the evolution of teaching. First, from the perspective of the teacher, why facilitate another's learning? Second, from the learner's perspective, why believe what another teaches you? Thus

far, research on teaching as a cooperative problem has not considered the problem from the perspective of the pupil.

Teacher as donor

From the perspective of a teacher, teaching may be costly in terms of (a) the effort required for teaching, and (b) future competition with skilled or knowledgeable pupils. In addition, teachers can (sometimes) be thought of as information donors (see Thornton & Raihani 2008 for review), especially if that information is otherwise costly to acquire. If there are costs of teaching, then there must be some benefit to the teacher, in order for teaching to evolve. Because the costs and benefits vary across different teaching types, the ways and degree to which benefits accrue to teachers should also be quite variable.

For example, teaching behaviors that require little teaching effort should be the most common, both across and within species. This is a prediction that is not made by other theories about the evolution of teaching, which tend to focus on the cognitive difficulties of teaching, rather than the cooperative costs involved. A priori, lower-effort forms of teaching behavior include: teaching via social tolerance, teaching via evaluative feedback, and teaching via local or stimuli enhancement. Higher-effort forms of teaching include opportunity provisioning —because the teacher must modify the environment and transform a learning situation — and direct, active teaching, because teachers may completely cease their ongoing activities in order to verbally and/or gesturally communicate abstract, generalizable knowledge to pupils. Of course, these a priori assertions ought to be tested in terms of measurable costs, such as time, opportunity, or energetic costs to teachers. However, the brief review of teaching behavior above seems to support this prediction—all else equal, the less costly forms of teaching seem to be more common across species, and the more costly forms more rare. Observational data from Fiji show

that relatedness predicts teaching between adult-child dyads, and that high-cost teaching types are less common (Kline, *in prep*; Chapter 3).

If teachers are donors, they may recoup costs through indirect fitness benefits, by selectively teaching biological kin. Based on Hamilton's (1964) rule, teaching should evolve only when the cost to the pupil for independent learning, discounted by the teacher/pupil relatedness, is less than the cost to the teacher (Dewar 2002, Hoppitt et al 2008). This suggests that teaching should be common among closely related individuals, and in species that breed cooperatively (van Schaik & Burkart 2010; Burkart & van Schaik 2009). Alternatively, it may be common where background relatedness within groups is high, and teaching happens within groups while resource competition happens between them (Taylor 1992). Where resource competition is primarily within the groups, background relatedness would have no such effect (Taylor 1992). This is consistent with the literature review above: relatively costly *teaching via opportunity provisioning* occurs in meerkats, which breed cooperatively (Thornton & McAuliffe 2006); other forms of teaching happen in pied babblers and tandem-running ants (see section on *psychologies of teaching*). High-cost forms of teaching including *direct active teaching* seem to be most common in humans, which have also been described as cooperative breeders (Hrdy 2008), and can be highly interdependent, which can have similar effects (Roberts 2005; Nettle et al. 2011; Tomasello et al. 2012). Such high-effort teaching is rare or absent in closely related chimpanzees (cf. Boesch 1991), which are not cooperative breeders.

Pupil as skeptic

Teaching is, in one form or another, modification of one individual's behavior by another's influence. This leaves the pupil open to manipulation by "cheating" teachers who deceive pupils for their own benefit, and suggests that pupils should practice epistemic vigilance to guard against inaccurate or deceptive teaching that harms their fitness (Sperber et al. 2010). Even

when teachers are the pupil's parents, pupil and teacher interests may differ—for example, parents often prefer to distribute resources across multiple offspring, while each individual offspring may prefer not to share with their siblings. This possibility should lead to counter-strategies used by skeptical pupils to resist manipulative teachers, while maintaining receptivity to credible teachers. Some of these strategies overlap with strategies for choosing good models for social learning more generally, while others are unique to teaching.

The teaching types outlined above differ in their potential for manipulation of pupils by teachers. Teaching types that work by eliciting, directing, or limiting the learner's individual learning are the least vulnerable to teacher abuse. This includes teaching via social tolerance, teaching by stimulus/local enhancement, and teaching by opportunity provisioning. In teaching by social tolerance, pupils are driven by internal motivations for social learning to seek access to another's behavior, and the "teaching" takes the form of tolerating the learner's interference. In order to achieve deception, a teacher would need to anticipate the learner's attention, and then perform the behavior in a way that would mislead the pupil to the advantage of the teacher. This type of deception would be cognitively demanding with limited effectiveness, especially if pupils have mental mechanisms for interpreting others' actions and goals, or for checking socially learned information against personal experience or observation. Similarly, teaching via stimulus or local enhancement is not prone to manipulation by selfish teachers, because teachers do not have direct influence on what pupils learn, but only facilitate pupils' individual learning by facilitating or directing their interest toward certain stimuli or sources of information. Teaching by opportunity provisioning functions similarly, as it depends on existing motives and nascent skill sets in the pupil. For instance, when social predators like meerkats provide their offspring with maimed prey, they have little effect on the pupil's motivations or the content of pupils' learning, but allow the learner to gain experience they could not achieve safely on their own. Pure opportunity provisioning will always have these properties. Since humans often mix

opportunity provisioning with other types of teaching (e.g., teaching via evaluative feedback, direct active teaching) in childhood chore assignments, opportunity provisioning *contexts* may be more prone to deception in humans—but this question is separate from the behavior of teaching via opportunity provisioning.

Teaching by evaluative feedback is more prone to abuse by selfish teachers, because its efficacy depends upon the teacher's ability to modify the learner's motivations or preferences. Even if the pupils' internal motivations were not affected, effective teaching by evaluative feedback would still change the likelihood of repeating a behavior that already exists in their repertoire. The problem of distinguishing deceptive from beneficial teaching via evaluative feedback is likely to be difficult for pupils, but might be achieved if pupils are selectively receptive to encouragement or discouragement that is consistent with their intrinsic motivations. Alternatively, pupils might be receptive to this type of teaching only from trustworthy teachers— for instance, close relatives who have little conflict of interest. Pupils may also validate teacher credibility by observing the teacher's behavior outside of the teaching context. When verification through observation alone is not possible, credibility-enhancing displays—behaviors that evidence a teacher's true belief—may evolve (Henrich 2009). Teaching via evaluative feedback is unique because it is low-cost for teachers, but high-risk for pupils. As such, this teaching type should be relatively common in its use by teachers, but often accompanied by resistance and skepticism by pupils.

Direct active teaching is exceptionally vulnerable to exploitation by selfish teachers because it is the only teaching behavior that may include the direct communication of abstract knowledge that can be entirely independent from related behavioral observation. (This is not the only mode through which direct active teaching may happen—gestural communication or direct active teaching through demonstration are also possible). As a result, learners should be skeptical of

such "cheap talk," and the consistency of teacher behavior with their teachings is especially important for pupil credulity (Sperber et al. 2010). Pupil skepticism may be conscious and explicit, or it may be captured in learning heuristics that select models who are likely to be knowledgeable and truthful, or that incorporate personal experience along with social learning.

While teachers may prefer to selectively teach close kin, learners may be more likely to trust teachers who are close kin, because inclusive fitness benefits mean that closely related teachers are less likely to deceive them. Pupils can also assume that kin have especially relevant knowledge, because they share genes and are likely to experience similar environments (Boyd & Richerson 1985, 1988). There is some evidence to support this conjecture: one experiment demonstrates that in the absence of information about accuracy, American 4-5 year old children prefer their mothers' verbal testimony about object names and functions over a stranger's (Corriveau et al., 2009). However, this preference is somewhat flexible; faced with accurate testimony from a stranger and inaccurate testimony from their mothers, some of these children persist in favoring testimony from their mothers.

In addition to preferring close kin as teachers, pupils may also choose to learn from teachers who are known to be accurate and reliable. Verifying teachers' claims against reality means the teacher is both knowledgeable and—at least in the past—truthful. This matters because learning from an honest-but-wrong teacher can be equally deleterious to a pupil's fitness as learning from a manipulative teacher. Even young children may be capable of such considerations. Several studies with U.S. children suggest 4-year olds are capable of distinguishing teacher quality, by tracking model accuracies, and preferring previously accurate models (Koenig et al 2004), knowledgeable models (Sabbagh & Baldwin 2001; Koenig et al 2005), and generally preferring accurate models when learning about novel object functions (Birch et al. 2008). Children also prefer accurate models over familiar ones when the models disagree (Corriveau &

Harris 2009), and will accept testimony from a presently well-informed model who was previously inaccurate due to being misinformed in the past—but will not "trust" information from a model who was both well-informed and inaccurate in the past (Nurmsoo & Robinson 2009). Children also seem to be capable of learning according to statistical evidence drawn from multiple observations of similar events, and can integrate this with information about the model (Buchsbaum et al 2011). (For an extensive review of the developmental psychology of children's learning in pedagogical contexts, see Skerry et al. 2013). These mechanisms only apply when the pupil can evaluate teacher accuracy, but outside the laboratory, accuracy and knowledge levels may be difficult for naïve learners to assess, especially when pupils depend upon teachers for learning about dangerous or causally opaque domains.

When direct verification of teacher accuracy is not possible, pupils may use alternative strategies. Learners might copy the most common behavior across a sample of teachers. This is true for social gossip, where information heard from more sources is rated as more credible (Hess and Hagen 2006). In addition, children are more likely to believe testimony endorsed by two informants in competition with a single one (Corriveau et al. 2009). Learners may also be credulous of teachers who are respected by third parties (Boyd & Richerson 1985), and may have originated as compensation to experts for the cost of teaching, and now allow learners to assess the quality of teachers based on the number of followers and extent of their deference (Henrich & Gil-White 2001). Consistent with this argument, 3-4 y.o. Canadian children prefer to imitate models who were observed by others rather than models who were not watched (Chudek et al. 2011). Many of these learning heuristics function outside of a teaching context to facilitate other types of social learning. However, they may be crucial to understanding how teaching can evolve, given the cooperative problems involved.

Finally, it may be that neither direct verification nor social indicators of teacher credibility are reliably available to pupils. In these conditions, when teachers profess beliefs in the abstract, a pupil may avoid manipulation by learning only from teachers who seem to act in accord with their own stated beliefs. For example, knowledge of particularly rich fishing grounds was a closely kept secret between highly competitive fishermen in pre-contact Hawaii—so much so, that if a deep-sea fisherman discovered a new productive location, he might share this information only with his children, even at the threat of physical assault (Kamakau 1976). In this situation, pupils should be skeptical of any information received—fishermen might misdirect others in order to protect their own preferred fishing grounds from becoming publicly known. Pupils should only believe fishermen who behave in ways that would be costly if their actual beliefs are in conflict with their stated beliefs—for instance, those who travel long distances to exploit particular fishing grounds. The same reasoning works for other behaviors, like not eating tasty but supposedly poisonous fruit. If such behaviors do not already exist, credibility-enhancing displays (CREDs) may culturally evolve along with beliefs, because they facilitate the spread of otherwise untestable beliefs (Henrich 2009). For example, abstaining from pleasurable but purportedly spiritually harmful behaviors like sex or alcohol consumption are behaviors that would be costly if the teachers' beliefs are false, and thus serve as evidence of a teacher's credibility. (It is not, however, evidence that a belief is true—only that the teacher believes it). These behaviors may be especially prevalent for the teaching beliefs that are difficult or dangerous to verify directly—including beliefs about disease transmission, poisonous foods, or supernatural beliefs.

Why humans teach more than other animals

The constraints of cognition and cooperation do not seem sufficient to explain why direct active teaching appears to be limited to humans, or why humans seem to be more prolific teachers in general in comparison to other species. How, then, can this be explained?

Based on the existing data and in light of the new framework proposed above, there are several possibilities. First, it may be that this is not a real difference. It could be that other species do use direct active teaching, but that because of a bias favoring the study of teaching in species with theory of mind and general cognitive capacities, researchers have been focusing on teaching in the wrong set of species. Similarly, it may be that there are simply more studies of human teaching than in any other species, so that a better sample might document teaching in non-human species. A related explanation is that existing operational criteria are too stringently focused on cost/benefit analyses, so that some cases of direct active teaching may go unreported.

Second, in a view consistent with existing mentalistic definitions, it may be that direct active teaching is uniquely human—and that this is due to our species' derived cognitive capacities. The existing framework suggests that direct active teaching could depend upon either theory of mind or metacognition and behavior-matching capacities (or both). This suggests that researchers should not limit the study of teaching to species with forms of mind-reading or theory of mind, because it is not an *a priori* necessity for teaching to evolve. In addition, theory of mind and degrees of mind-reading capacities are notoriously difficult to identify even in species that are closely related to humans (see for example, Call & Tomasello 2008; Penn & Povinelli 2007; Heyes 1998), which makes a ToM-centered approach impractical. This is in part because of a focus on false belief tasks as the test for theory of mind, a practice that is itself of debatable value (Bloom & German 2000).

Rather than focus on psychological prerequisites for teaching, researchers ought to focus on an evolutionary cost-benefit analysis to target the study of teaching: in what socioenvironmental niche is teaching adaptive? This might include species with cooperative breeding, interdependence, or heavy parental investment in offspring. It might also include species that

depend on socially learned information for adapting to a spatiotemporally variable environment. From this perspective, it may be more profitable to compare humans to taxa like cetaceans— some species of which depend on complicated, socially learned foraging and hunting techniques (Rendell & Whitehead 2001)—rather than to focus exclusively on primate comparisons. This shift in focus may lead to a change in the data researchers collect on direct active teaching, as well as other teaching types.

Based on this approach, the simplest and most likely explanation for why direct active teaching is present only in humans is that ours is the only species in which it is adaptive—that is, ours is the only species in which the frame problem is fitness-relevant. This is the case because humans (and only humans) evolved in the "cultural niche," such that our species depends to a great degree on cumulative cultural adaptations too complex for any one individual to create on his own, and as a result we evolved unique cultural capacities (Boyd et al. 2011). If this is the case, then direct active teaching may be a derived form of teaching that coevolved with culture, for the purpose of transmitting hard-to-learn cultural adaptations. Testing this explanation requires an integrated, unifying framework of the study of teaching across species and societies like the one proposed above.

Conclusion

To date the study of teaching has been conducted from three different perspectives, each of which focuses on a particular teaching type without framing it in the broader range of variation in teaching behavior across cultures and taxa. This has led to definitional disagreements across disciplines about which behaviors in what contexts can properly be crowned "teaching," and which can not, but those debates have not led to a robust comparative definition until now. This paper refocuses the study of teaching on categorizing and studying an array of teaching types, based on a framework of adaptive problems that teaching solves for social learners. This

framework can be used to integrate the empirical literature on teaching in human and non-human animals, and highlights two major areas of inquiry in the evolution of teaching: psychological underpinnings, and cooperative dilemmas.

In light of this new framework, it makes little sense to focus research on establishing that a species or specific human population "has teaching" or "does not have teaching," particularly where an example can be excluded based on a single dimension, such as a cost/benefit analysis, or evidence of psychological capacities like mind-reading or intentionality. Instead, researchers should identify the adaptive problem that teaching solves in a particular context or environment of evolutionary adaptiveness, and quantify outcomes in terms of the frequency and duration of teaching events. Teaching should be distinguished from baseline behavior on a case-by-case basis, with operational rules tied to the theoretical definitions at work, but with the particular species and behavioral domain in mind. Developing these practical methods requires differentiating between social learning contexts in which different teaching types may evolve, because the identifying characteristics of teaching behavior vary by type.

References

Adams, M. J., Treiman, R., & Pressley, M (1998) Reading, writing, and literacy. In: Handbook of child psychology: Vol.4. Child psychology in practice. (Eds. W. Damon, I. Sigel, & K. Renninger), pp.275–355. Wiley.

Akhtar, N, and M A Gernsbacher (2008) On Privileging the Role of Gaze in Infant Social Cognition. Child Development Perspectives 2: 59-65.

Baldwin, D., J. Baird, M. Saylor, and M. Clark (2001) Infants parse dynamic action. Child Development: 708-717.

Basso, Keith H. (1972) Ice and Travel among the Fort Norman Slave: Folk Taxonomies and Cultural Rules. Language in Society **1**(1): 31–49.

Bender, C., D. Herzing, and D. Bjorklund (2009) Evidence of teaching in atlantic spotted dolphins *(Stenella frontalis)* by mother dolphins foraging in the presence of their calves. Animal cognition 12:43-53.

Birch, S., S. Vauthier, and P. Bloom. (2008) Three-and four-year-olds spontaneously use others' past performance to guide their learning. Cognition 107:1018-1034.

Bird, Douglas W, and Rebecca Bliege-Bird (2002) Children on the Reef: Slow Learning or Strategic Foraging? Human Nature 13: 269–297.

Bliege-Bird, Rebecca, and Douglas W Bird. (2002) Constraints of Knowing or Constraints of Growing?: Fishing and Collecting by the Children of Mer. Human Nature 13: 239–267.

Bloom, P., & German, T. P. (2000). Two reasons to abandon the false belief task as a test of theory of mind. *Cognition*, *77*(1), B25-B31.

Bock, John. (2002) Learning, Life History, and Productivity: Children's Lives in the Okavango Delta, Botswana. Human Nature 12: 161–197.

Boesch, C. (1991) Teaching among wild chimpanzees. Animal Behaviour 41: 830.

Boyd, R., and P. J. Richerson (1985) Culture and the Evolutionary Process. The University of Chicago Press.

Boyd, R., & P.J. Richerson (1988) An evolutionary model of social learning: The effects of spatial and temporal variation. In: Social learning: A psychological and biological approach, eds. T. Zentall & B. G. Galef, 29-48. Erlbaum.

Boyd, R., & Richerson, P. J. (1996). Why culture is common but cultural evolution is rare. *Proceedings of the National Academy of the Sciences of the United States*, *108*, 10918–10925.

Boyd, R., Richerson, P. J., & Henrich, J. (2011). Colloquium Paper: The cultural niche: Why social learning is essential for human adaptation. *Proceedings of the National Academy of Sciences*, *108*, 10918–10925. doi:10.1073/pnas.1100290108

Boyer, Pascal. (1998) Cognitive Tracks of Cultural Inheritance: How Evolved Intuitive Ontology Governs Cultural Transmission. American Anthropologist 100: 876–889.

Brand, R.J., Baldwin, D.A., & Ashburn, L.A. (2002). Evidence for 'motionese': modifications in mothers' infant-directed action. Developmental Science, **5**, 72–83.

Briggs, J. 1998. Inuit Morality Play: The Emotional Education of a Three-Year-Old. Yale University Press.

Browne, D (2004) Do dolphins know their own minds? Biology and Philosophy 19:633-653.

Bryant, G. A., & Barrett, H. C. (2007). Recognizing Intentions in Infant-Directed Speech: Evidence for Universals. *Psychological Science*, *18*(8), 746–751. doi:10.1111/j.1467-9280.2007.01970.x

Buchsbaum, D., Gopnik, A., Griffiths, T. L., & Shafto, P. (2011). Children's imitation of causal action sequences is influenced by statistical and pedagogical evidence. *Cognition*, *120*(3), 331-340.

Burkart, J. M., Hrdy, S. B. & van Schaik, C. P. (2009) Cooperative breeding and human cognitive evolution. Evolutionary Anthropology 18: 175-186.

Byrne, R. W. 1999. Imitation without intentionality. Using string parsing to copy the organization of behaviour. Animal cognition 2: 63-72.

Byrne, Richard W, and Lisa G Rapaport. (2011) What Are We Learning From Teaching? Animal Behaviour 82: 1207–1211.

Carey, S. 2000. Science Education as Conceptual Change. Journal of Applied Developmental Psychology 21:13-19.

Caro, TM. (1980) Predatory Behaviour in Domestic Cat Mothers. Behaviour 74: 128–148.

Caro, T., and M. Hauser (1992) Is there teaching in nonhuman animals? Quarterly Review of Biology 67: 151-174.

Cazden, C., and V.P. John. (1971) Learning in American Indian Children. In: Anthropological Perspectives on Education, eds. M. L. Wax, S. Diamond, and F. O. Gearing. 252–272. Basic.

Chudek, M., Heller, S., Birch, S., & Henrich, J (2011) Prestige-biased cultural learning: bystander's differential attention to potential models influences children's learning. Evolution and Human Behavior: 1–11.

Corriveau, K., and P. Harris. (2009) Choosing your informant: weighing familiarity and recent accuracy. Developmental Science 12: 426-437.

Corriveau, K., P. Harris, E. Meins, C. Ferneyhough, B. Arnott, L. Elliot, B. Liddle, A. Hearn, L. Vittorini, and M. de Rosnay (2009) Young children's trust in their mothers' claims: Longitudinal links with attachment security in infancy. Child Development 80: 750-761.

Coy, M. W. (Ed.). (1989) Apprenticeship: From theory to method and back again. SUNY Press.

Csibra, G. (2007) Teachers in the Wild. TRENDS in Cognitive Sciences 11: 95–96.

Csibra, G, and G Gergely (2011) Natural Pedagogy as Evolutionary Adaptation. Philosophical Transactions of the Royal Society B: Biological Sciences 366: 1149–1157.

Csibra, G, and G Gergely (2009) Natural Pedagogy. TRENDS in Cognitive Sciences 13: 148–153.

Curran, HV. (1980) Cross-Cultural Perspectives on Cognition. In: Cognitive Psychology: New Directions (ed. G. Claxton), 300-334. Routledge & Kegan Paul.

Davis-Unger, AC, and SM Carlson (2008) Development of Teaching Skills and Relations to Theory of Mind in Preschoolers. Journal of Cognition and Development 9: 26–45.

Dawkins, R. (1982). The extended phenotype. San Francisco: Freeman Press.

Dean, L. G., Kendal, R. L., Schapiro, S. J., Thierry B, & Laland, K. N. (2012). Identification of the Social and Cognitive Processes Underlying Human Cumulative Culture. *Science*, *335*(6072), 1114–1118. doi:10.1126/science.1213969

Dewar, G. 2002. The cue reliability approach to social transmission: how animals use social and nonsocial cues to identify safe, new options. Ph.D. thesis, University of Michigan.

Ewer, R.F. (1969) The instinct to teach. Nature 222: 698.

Fairbanks, L. 1975. Communication of food quality in captive *Macaca nemestrina* and free-ranging *Ateles geoffroyi*. *Primates* 16: 181-190.

Fernald, A., & Mazzie, C. (1991). Prosody and focus in speech to infants and adults. Developmental Psychology, **27**, 209– 221.

Franks, N., & Richardson, T. (2006). Teaching in tandem-running ants. *Nature*, *439*(7073), 153.

Gaskins, S., and R. Paradise. (2010) Learning Through Observation in Daily Life. In: The Anthropology of Learning in Childhood, ed. D.F .Lancy, J. Bock, & S. Gaskins. AltaMira Press.

Geertz, C. (1961) The Javanese family: A study of kinship and socialization. Free Press.

Gergely, G., Egyed, K., & Király, I. (2007). On pedagogy. *Developmental Science*, *10*(1), 139–146. doi:10.1111/j.1467-7687.2007.00576.x

Gourgey, A. (1998) Metacognition in basic skills instruction. Instructional Science 26: 81-96.

Gottlieb, A. (2004) The afterlife is where we come from. University of Chicago.

Guberman, Steven R, and Patricia M Greenfield. (1991) Learning and Transfer in Everyday Cognition. Cognitive Development 6: 233–260.

Hamilton, W. D. (1964). The genetical evolution of social behaviour. II. *Journal of theoretical biology*, *7*(1), 17-52.

Henrich, J. (2009) The evolution of costly displays, cooperation and religion: credibility enhancing displays and their implications for cultural evolution. Evolution and Human Behavior 30: 244-260.

Henrich, J., and R. Boyd. (1998) The evolution of conformist transmission and the emergence of between-group differences. Evolution and Human Behavior 19 : 215-241.

Henrich, J., & Boyd, R. (2002). On modeling cognition and culture. *Journal of Cognition and Culture*, *2*(2), 87-112.

Henrich, J., Boyd, R., & Richerson, P. J. (2008). Five misunderstandings about cultural evolution. *Human Nature*, *19*(2), 119-137.

Henrich, J., and F. J. Gil-White. (2001) The evolution of prestige: freely conferred deference as a mechanisms for enhancing the benefits of cultural transmission. Evolution and Human Behavior 22: 165-196.

Henrich, Joseph, S.J. Heine, A. Norenzayan (2010) The Weirdest People in the World? Behavioral and Brain Sciences 33: 61–83.

Heyes, C. M. (1998). Theory of mind in nonhuman primates. *Behavioral and Brain Sciences*, *21*(1), 101-114.

Hess, N., and E. Hagen (2006) Psychological adaptations for assessing gossip veracity. Human Nature 17: 337-354.

Hewlett, B. S., Fouts, H. N., Boyette, A. H., & Hewlett, B. L. (2011) Social learning among Congo Basin hunter-gatherers. Philosophical Transactions of the Royal Society B: Biological Sciences 366: 1168–1178.

Hikami, K., Hasegawa, Y., and Matsuzawa, T. 1990. Social transmission of food preferences in Japanese monkeys *(Macaca fuscata)* after mere exposure or aversion training. *Journal of Comparative Psychology* 104: 233-237.

Hill, K., Barton, M., & Hurtado, A. M. (2009). The emergence of human uniqueness: Characters underlying behavioral modernity. *Evolutionary Anthropology Issues News and Reviews*, *18*(5), 187–200. doi:10.1002/evan.20224

Hocart, A. M. (1929). Lau Islands, Fiji. Honolulu: Bernice P. Bishop Museum

Hogbin, H. I. (1970) A New Guinea childhood: From weaning till the eighth year in Wogeo, In: From Child to Adult, ed. J. Middleton, 124-62 The Natural History Press.

Hoppitt, W., G. R. Brown, R. Kendal, and L. Rendell (2008) Lessons from animal teaching. TRENDS in Ecology & Evolution 23: 486-493.

Hrdy, S. 2008. Evolutionary context of human development: the cooperative breeding model. In: Family Relationships: an evolutionary perspective, eds C. Salmon and T. Kennedy, Oxford University Press.

Iverson, Jana M., et al. "Gesturing in mother-child interactions." *Cognitive Development* 14.1 (1999): 57-75.

Kamakau, S. M. (1976) The works of the people of old: Na hana a ka po'e kahiko. Bishop Museum Press.

Karmiloff-Smith, A. (1985) From meta-processes to conscious access: Evidence from children's

metalinguistic and repair data. Cognition 23: 95-147.

Kirch, P. V. (2002). *On the Road of the Winds-An Archaeological History of the Pacific Islands Before European Contact.* University of California Press.

Koenig, M., and P. Harris (2005) Preschoolers mistrust ignorant and inaccurate speakers. Child Development 76: 1261-1277.

Koenig, M., F. Clement, and P. Harris (2004) Trust in Testimony. Psychological Science 15: 694-698.

Kline, M. A., Boyd, R., & Henrich, J. (2013). Teaching and the Life History of Cultural Transmission in Fijian Villages. *Human Nature*, *24*(4), 351–374. doi:10.1007/s12110-013-9180-1

Kruger, A., and M. Tomasello (1996) Cultural Learning and Learning Culture. In: The Handbook of Education and Human Development, Eds. D. Olson and N. Torrance. Blackwell Publishers.

Kruuk, H. and & M. Turner (1967) Comparative notes on predation by lion, leopard, cheetah and wild dog in the Serengeti area, East Africa. Mammalia 31: 1-127.

Laguna, F. (1965) Childhood among the Yakutat Tlingit. In: Context and Meaning in Cultural Anthropology. ed., M. Spiro, 3–23. Free Press.

Lancy, D.F. (2007) Accounting for Variability in Mother-Child Play. American Anthropologist 109: 273–284.

Lancy, D.F. (2008) The Anthropology of Childhood. Cambridge University Press.

Lancy, D.F. (2010) Learning 'From Nobody': the Limited Role of Teaching in Folk Models of Children's Development. Childhood in the past. 79-106.

Lancy, D.F., and M.A. Grove (2010) The Role of Adults in Children's Learning. In: The Anthropology of Learning in Childhood. Ed. D.F. Lancy, J Bock, & S. Gaskins. AltaMira Press.

Lave, J, and E. Wenger (1991) Situated learning: Legitimate peripheral participation. Cambridge University Press.

Lee, D. (1967) A Social-Anthropological View of Independent Learning. In: The Theory and Nature of Independent Learning, Ed. G.T. Gleason. 51–63. International Textbook.

Levy, R. I. (1996) Essential contrasts: Differences in parental ideas about learners and teaching in Tahiti and Nepal. Parents' cultural belief systems, Eds. S. Harkness and C. Super, 123-142. Guilford Press.

Liers, EE. (1951) Notes on the River Otter (Lutra Canadensis). Journal of Mammalogy 32: 1–9.

Lopez, J.C. & D. Lopez. (1985) Killer whales of Patagonia and the behavior of intentional stranding while hunting nearshore. Mammalia 66: 181-183.

Macdonald, K. (2007) Cross-Cultural Comparison of Learning in Human Hunting. Human Nature 18: 386–402.

Maestripieri, D. (1995). First steps in the macaque world: do rhesus mothers encourage their infants' independent locomotion?. *Animal Behaviour*, *49*(6), 1541-1549.

Maestripieri, D. (1996). Maternal encouragement of infant locomotion in pigtail macaques, Macaca nemestrina. *Animal Behaviour*, *51*(3), 603-610.

Masataka, N., Koda, H., Urasopon, N., & Watanabe, K. (2009). Free-Ranging Macaque Mothers Exaggerate Tool-Using Behavior when Observed by Offspring. (L. Santos, Ed.)*PLoS ONE*, *4*(3), e4768. doi:10.1371/journal.pone.0004768.g002

McPhee, C. (1969) Children and Music in Bali. In: Children in Contemporary Cultures. Eds. M. Mead and M. Wolfenstein, 70–98. Chicago University Press.

Mead, M. (1970) Our educational emphases in primitive perspective. In: From child to adult: Studies in the anthropology of education. Vol. 12, Ed. J. Middleton, The Natural History Press.

Nettle, D., Panchanathan, K., Rai, T. S., & Fiske, A. P. (2011). The evolution of giving, sharing, and lotteries. *Current Anthropology*, *52*(5), 747-756.

Nicol, C., & Pope, S. (1996). The maternal feeding display of domestic hens is sensitive to perceived chick error. *Animal Behaviour*, *52*(4), 767–774.

Nurmsoo, E., and E. Robinson (2009) Children's Trust in Previously Inaccurate Informants Who Were Well or Poorly Informed: When Past Errors Can Be Excused. Child development 80: 23-27.

Olson, D.R. & J.S. Bruner (1996) Folk psychology and folk pedagogy. In: The Handbook of Education and Human Development, Eds. D. Olson and N. Torrance. Blackwell Publishers.

Paradise, R., and B. Rogoff (2009) Side by Side: Learning by Observing and Pitching in, Ethos 37: 102–138.

Pearson, A.T. (1989) The teacher: theory and practice in teacher education. Routledge.

Pelissier, C. (1991) The Anthropology of Teaching and Learning. Annual Review of Anthropology 20: 75–95.

Penn, D. C., & Povinelli, D. J. (2007). On the lack of evidence that non-human animals possess anything remotely resembling a 'theory of mind'. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *362*(1480), 731-744.

Perreault, C. (2012) The Pace of Cultural Evolution. PLoS ONE 7: e45150.

Pettitt, George A. (1946) Primitive Education in North America. University of California Publications in American Archaeology and Ethnology 43. University of California.

Premack, D., & Premack, A. (2004) Education for the prepared mind. Cognitive Development 19: 537–549.

Ridley, A. R., & Raihani, N. J. (2007). Variable postfledging care in a cooperative bird: causes and consequences. *Behavioral Ecology*, *18*(6), 994-1000.

Raihani, N., & Ridley, A. (2008). Experimental evidence for teaching in wild pied babblers. *Animal Behaviour*, *75*(1), 3–11.

Rapaport, LG, and CR Ruiz-Miranda. (2002) Tutoring in Wild Golden Lion Tamarins. International Journal of Primatology 23: 1063–1070.

Reichard, G. (1934) Spider Woman. A Story of Navaho Weavers and Chanters. MacMillan.

Rendell, L., & Whitehead, H. (2001). Culture in whales and dolphins. *Behavioral and Brain Sciences*, *24*, 309-382.

Richardson, T. O., Sleeman, P. A., McNamara, J. M., Houston, A. I., & Franks, N. R. (2007). Teaching with Evaluation in Ants. *Current Biology*, *17*(17), 1520–1526. doi:10.1016/j.cub.2007.08.032

Ritchie, J. B., & Ritchie, J. E. (1979). Growing up in Polynesia. Worthing: Littlehampton Book Svc.

Roberts, G. (2005). Cooperation through interdependence. *Animal Behaviour*,*70*(4), 901-908.

Rogoff, B. (1981) Schooling and the development of cognitive skills. Handbook of Cross-Cultural Psychology, Vol 4, Eds. HC Triandis and A Heron, 233-294, Allyn & Bacon.

Rogoff, B., R. Paradise, R.M. Arauz, M. Correa-Chavez, C. Angelillo (2003) Firsthand Learning Through Intent Participation. Annual Review of Psychology 54: 175–203.

Sabbagh, M. A., & Baldwin, D. A. (2001). Learning words from knowledgeable versus ignorant speakers: Links between preschoolers' theory of mind and semantic development. *Child development*, *72*(4), 1054-1070.

van Schaik, C. P. & Burkart, J. M. (2010) Mind the gap: cooperative breeding and the evolution of our unique features. In: Mind the Gap: Tracing the Origins of Human Universals, Ed. P. M. Kappeler & J. B. Silk, 477-496. Springer.

Schaller, G.B. (1967) The deer and the tiger. Chicago University Press.

Smith, J. D., W. E. Shields, and D. A. Washburn (2003) The comparative psychology of uncertainty monitoring and metacognition. Behavioral and Brain Sciences 26: 317-339.

Snow, C. 1995, Issues in the study of input: Finetuning, universality, individual and developmental differences, and necessary causes. In: *The Handbook of Child Language*, Ed. P. Fletcher & B. MacWhinney, 180-193. Oxford: Basil Blackwell.

Sperber, D. 2000. Metarepresentations in an evolutionary perspective. Metarepresentations: 117-137.

Sperber, D. & D. Wilson (1995) Relevance: communication and cognition, 2nd edition. Blackwell.

Sperber, D., Clément, F., Heintz, C., Mascaro, O., Mercier, H., Origgi, G., & Wilson, D. (2010). Epistemic vigilance. *Mind & Language*, *25*(4), 359-393.

Spindler, G., & L. Spindler (1989) What do Anthropologists have to say about dropouts: 7-15.

Strauss, C. (1984) Beyond 'Formal' Versus 'Informal' Education: Uses of Psychological Theory in

       Anthropological Research. Ethos: 195–222.

Strauss, S, M Ziv, and A Stein (2002) Teaching as a Natural Cognition and Its Relations to

       Preschoolers' Developing Theory of Mind. Cognitive Development 17: 1473–1487.

Tanon, F. (1994) A cultural view on planning: The case of weaving in Ivory Coast. Tilburg University

       Press.

Taylor, P. (1992) Altruism in viscous populations: an inclusive fitness model. Evolutionary Ecology 6:

       352-356.

Tennie, C., Call J, & Tomasello, M. (2009). Ratcheting up the ratchet: on the evolution of cumulative

       culture. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1528),

       2405–2415. doi:10.1098/rstb.2009.0052

Thornton, A, NJ Raihani, and AN Radford. (2007) Teachers in the Wild: Some Clarification. TRENDS

       in Cognitive Sciences 11: 272–273.

Thornton, A., and K. McAuliffe (2006) Teaching in wild meerkats. Science 313: 227-229.

Thornton, A, and K. McAuliffe (2012) Teaching Can Teach Us a Lot. Animal Behaviour 83: e6–

       e9.

Thornton, A, and N Raihani (2008) The Evolution of Teaching. Animal Behaviour 75: 1823–1836.

Tomasello, M. (1999) The Human Adaptation for Culture. Annual Review of Anthropology 28: 509.

Tomasello, M., M. Carpenter, J. Call (2005) Understanding Sharing Intentions: the Origins of Cultural

       Cognition. Behavioral and Brain Sciences 28: 675–735.

Tomasello M, Kruger AC, and Ratner HH. (1993) Cultural Learning. Behavioral and Brain Sciences 16:

       495-552

Tomasello, M., Melis, A. P., Tennie, C., Wyman, E., & Herrmann, E. (2012). Two Key Steps in the

       Evolution of Human Cooperation: The Interdependence Hypothesis, 1–21. doi:10.1086/668207

van Schaik, C., M. Ancrenaz, G. Borgen, B. Galdikas, C. Knott, I. Singleton, A. Suzuki, S. Utami, and M.

       Merrill (2003) Orangutan cultures and the evolution of material culture. Science 299: 102.

Vygotsky, L.S. (1978) Mind in Society: The Development of Higher Psychological Processes. Harvard
University Press.

Wellman, HM, and KH Lagattuta (2004) Theory of Mind for Learning and Teaching: the Nature and
Role of Explanation. Cognitive Development 19: 479–497.

Whiten, A., & Erdal, D. (2012). The human socio-cognitive niche and its evolutionary origins.
Philosophical Transactions of the Royal Society B: Biological Sciences, *367*(1599), 2119–2129.
doi:10.1098/rstb.2012.0114

Wilbert, Johannes. (1976) To become a maker of canoes: An essay in Warao enculturation. UCLA Latin
American Studies Series and Latin American Studies Los Angeles, Cal. 37: 303-358.

Ziv, M, and D Frye. (2004) Children's Understanding of Teaching: the Role of Knowledge and Belief.
Cognitive Development 19: 457–477.

CHAPTER 3

Forms and functions of teaching in early childhood

Evidence from focal follows in Fijian villages

Introduction

Humans have adapted to a broad range of environments, from the arctic to the tropics. In large part this has been through processes of cultural as opposed to genetic adaptation (Boyd et al 2011). While the adaptive nature of cultural practices has long been recognized, explicit theoretical treatments of the processes that give rise to adaptive practices have only recently been developed. Early anthropologists carefully documented the functionality of traditional technology, and midcentury ecological functionalist authors (e.g. Harris 1979) emphasized the importance of adaptation in explaining cultural practices. However, only in the last several decades has there been an explicit theoretical treatment that linked individual attributes—how people learn on their own and from others—to long term cultural evolution. These new models are rooted in the idea that culture is information stored in human brains, and transmitted through time via teaching, imitation, and other kinds of social learning (e.g. Cavalli-Sforza & Feldman 1981, Boyd and Richerson 1985, Sperber 1996, Henrich and McElreath 2003, Mesoudi 2011).

Teaching in particular is thought to be important in making faithful cultural transmission possible, for example when social learning problems are difficult due to task opacity or complexity (Csibra & Gergely 2009, 2011). More generally, teaching may be one of a few sociocognitive mechanisms that make cumulative cultural evolution possible in humans (Dean et al. 2012; see also Boyd & Richerson 1985, Tomasello 1993). However, to evaluate the veracity of these claims, researchers need a theoretical framework to distinguish between the kinds of

teaching behaviors that have evolved in humans and those that have evolved and been documented in other animals (see Kline *in prep,* Chapter 2). In addition, researchers need a robust data to evaluate the evolved form and function of teaching behaviors across human societies, and in contrast to non-human animals. If teaching is a key to cumulative cultural evolution in humans, such data ought to demonstrate that some forms of teaching are unique to humans—or at least much more common than in other animals—and that they are panhuman traits, present across a range of socioecological contexts.

Teaching has been functionally defined as behavior evolved to facilitate learning in others (Caro & Hauser 1992), and as a cooperative behavior (e.g., Dewar 2002, Galef et al. 2005, Thornton & McAulliffe 2012). This includes behaviors that facilitate learning by (a) granting a learner access to relevant stimuli, (b) creating or directing a learner's attention toward relevant stimuli, or (c) both stimulating attention *and* granting access to relevant stimuli, simultaneously (Kline, *in prep,* Chapter 2). Teaching types can also differ in terms of teaching effort. While most teaching types are relatively low effort in that they involve simple manipulation of pupil attention or access, direct active teaching and teaching by opportunity provisioning—a form of teaching in which the teacher creates access to stimuli or experiences to facilitate pupil learning—are both thought to require relatively high teaching effort, in that they require potential teachers to abandon their own activities in order to interact with a pupil or modify the pupil's environment, to a greater degree than for other teaching types (see Kline *in prep,* Chapter 2).

Despite recent interest in the theoretical importance of teaching in human evolution and social development (for review see Kline *in prep*, Chapter 2), the form and function of human teaching behaviors outside of Western classrooms is not well understood. The range of teaching behaviors that have been documented in non-human animals (see Kline *in prep,* Chapter 2 for review; see also Hoppitt et al. 2008 and Caro & Hauser 1992) are probably also important in

human learning. Unfortunately, evolutionarily motivated empirical work on naturally occurring teaching in humans is limited to a study of Congo basin hunter-gatherers (Hewlett et al. 2011), and a set of interviews with Fijian fishing-horticulturalists (Kline et al. 2013). Hewlett et al. (2011) used a mix of qualitative and quantitative methods to find that teaching, while rare, is present in Aka and Bofi hunter-gatherer societies—including in domains such as basket weaving and distinguishing edible from inedible plants. Kline et al. (2013) found that teaching is more frequent during vertical transmission (from grandparent/parent to offspring), and for high skill tasks learned later in life, in fishing-horticultural populations in Fiji.

Aside from these two studies, existing work on human teaching outside the West and outside classrooms is suggestive of cross-cultural differences, but does not include the kind of fine-grained data on individual and contextual variation in teaching behavior that is necessary to test evolutionary hypotheses about the form and function of teaching. Specifically, existing data cannot tell us about the prevalence of teaching within (or across) human populations, because ethnographic data are not systematically sampled or controlled. Existing data also cannot speak to whether the behavioral patterns are consistent with evolutionary predictions derived from an ultimate explanation of the function of teaching. Cultural anthropologists who study teaching in non-Western societies continue to argue that teaching as a general phenomenon is rare or absent outside the classroom (Lancy & Grove 2011), and that teaching is less important than more interactive learning, which is characterized as participant observation or "pitching in" (Rogoff et al. 2003, Paradise & Rogoff 2009). This work provides rich and detailed descriptions of children's lives and experiences, and can illustrate the situated social contexts that shape the social learning problems that teaching (and other adaptations) may have evolved to solve. However, it is not clear how reliably teaching is identified in such studies, as ethnographers often rely on intuitive, culture-bound definitions of teaching (see Kline *in prep,* Chapter 2 for critique of this approach). Such studies rarely deploy systematic sampling, meaning that their

claims about the absence or frequency of teaching may not be reliable for testing claims about the prevalence, importance, or context-dependent variation in teaching behaviors in non-Western societies.

This paper provides quantitative data on the rates and patterns of teaching derived from focal follows of young children (6y.o. and younger) living in small fishing-horticultural villages in the Yasawa Islands, Fiji. With these data, I empirically test predictions about the adaptive form and function of teaching outside of the West, and outside of a classroom context. More specifically, this paper addresses the following research problems. First, some anthropologists have claimed that teaching is rare or absent in non-Western societies, and have used Fiji as an example in making such claims (e.g., Lancy 2008). By explicitly defining an ethogram of teaching behaviors and systematically recording these behaviors during focal follows of Fijian children, this study aims to document the frequency of subtle and overt forms of teaching. Further, the data analyzed here allow for a comparison of the prevalence of a range of different teaching behaviors. Second, this paper addresses whether there is evidence for the adaptive deployment of teaching, for example according to fitness-relevant costs and benefits to the teacher. If this is the case, then, all else equal, teaching types that require high levels of teaching effort (a direct cost to a potential teacher) should be less common than those that require low levels of teaching effort. Similarly, since teachers can receive indirect benefits that may offset teaching effort costs, teaching should be more common among closely related individuals, when controlling for their rates of association.

Ethnographic Context

Data presented here were collected during 2011-2012 in two Fijian villages on Yasawa Island, over the course of 15 months. This island is located in the Northwestern corner of the Fijian Islands. These villages have populations of about 100- 250 each, and are sustained primarily by

a subsistence economy consisting of cassava and yam horticulture, along with fish and seafood gathered from the reef. Political units are composed of interrelated patri-clans, governed by a council of elders and a hereditary chief, and life is organized by a complex web of kinship relations and obligations. Dialects across the villages are closely related but variable. There are no local markets, broadcast television, automobiles, or public utilities in these villages. Radios are common and cell phones have become increasingly prevalent since 2009, though a lack of a reliable source of electricity, unreliable service, and the difficulty of purchasing minutes limits their usage.

Despite the introduction of British-style formal schooling in the early 1900's (see White 2007), Fijian childhood in these relatively traditional villages remains quite different from childhood in the Western world, making for a valuable cross-cultural comparison of cultural learning. This paper focuses on the role of subtle and overt teaching in everyday interactions between young children and others. In this and many other Fijian villages, social interactions including those relevant to cultural learning are shaped by the relative social status and kinship relationships of the actors (Sahlins 1962; Toren 1990, Brison 1999; Ravuvu 1983; Nayacakalou 1975). Relationship norms structure interactions so that subordinates do not dominate an interaction nor set its terms by direct questioning (Nabobo-Baba 2006, Arno 1990). This is a recurring pattern in Polynesia (e.g., Ritchie and Ritchie 1979; Borofsky 1987). Many village rules about hierarchy do not apply to infants and very young children, who are thought to be incapable of comprehension. According to Hocart's study in the Lau region of Fiji, infants are said to be "without minds," and young children are "watery-souled" (Hocart, 1929 p146).

As is typical in the Pacific (Ritchie and Ritchie 1979) and across the world, Fijian parents are not expected to actively instruct very young children (see also Ochs and Schieffelin 1984), children are not encouraged to ask questions, and they are expected to contribute to household chores

from the age of 7-8 (see Kline et al. 2013; see also Lancy and Grove 2011, Lancy 2008, Bock 2002, c.f. hunter-gatherer groups: Hewlett and Lamb 2007). In traditional villages in Fiji, legitimate ways of learning include: learning by (a) listening either to an established elder's telling or chatting *(talanoa)* or to rules as frequently repeated by parents (Nabobo-Baba 2006), (b) learning by experience either as a helper who is sometimes corrected (Ritchie and Ritchie 1979), or (c) individually, through pseudo-experimental trial-and-error (Nabobo-Baba 2006). As discussed by Kline et al. (2013), parents recognize schooling as a means of learning about some things, and most children in the village attend primary school somewhat regularly between the ages of 7 and 14. In the second of the two villages in this study, there is a one-room preschool with one teacher, that children attend periodically for half-days from the ages of about 3-6 years old. The preschool lessons are mostly spent learning to sing children's songs, with some literacy work (For example, learning to draw letters or drawing freely on chalk-boards, depending on a child's age, and learning the English words for colors). Most adults in the population have completed primary school or have some secondary school education. However, as elsewhere in Fiji, parents in these villages seem to think of schooling mainly as a means for gaining future employment through fluency in English, rather than for success within traditional village life or as a goal that is valuable in itself (Brison 2007; Veramu 1992), so that villagers generally rate more-educated individuals as having less knowledge of important domains of work within the village (Henrich & Broesch, 2011). Children must still fulfill an economic role in the household, with priority apparently given to chores over homework (Dakuidreketi 2006, Veramu 1992). This suggests that though formal schooling is admired by many in Fiji, growing up in a Yasawan village is still quite different from growing up in a Western, educated, industrialized and rich society (see Henrich et al. 2010).

Methods

I collected focal follow data (Altmann 1974) for 51 Fijian children aged 1 to 6 years old, in two villages on Yasawa Island. Because the follows were conducted over a period of 3-4 months in each village, age data for children are rounded up to the nearest year. Each focal follow lasted 20 minutes and the focal child was randomly selected from a list of children in the village. All parents and families agreed to participate prior to these follows, such that the sample includes all children in this age range in both villages. The total number of follows is 204, with an average of between 4 and 5 follows per child, with a standard deviation of 2.8. I recorded behavior by and toward the focal child continuously during each follow, at a rate of about 1-2 entries every 3-4 seconds, and according to a pre-designed ethogram that included key behavioral indicators of theorized teaching types (see Table 3-1 and *ethogram design*, below).

Follows were only conducted during daylight hours, and families were not told ahead of time when I would observe a particular child. Follow start times were randomly generated, and a focal child was randomly assigned to each time block. To do this, I divided the day into two time blocks (6:30 AM-12:30 PM, and 12:30PM – 6:30 PM), and three start times were randomly generated within each of those time blocks. The time blocks were necessary to ensure that times were somewhat spread out across the day. When randomly generated start times were scheduled less than 20 minutes apart (the length of one follow), they were completed in order immediately one after the other. Focals were sampled without replacement by generating a randomly ordered list of focal individuals, and assigning each focal to an observation period according to the list's order. If a focal was not available during a scheduled follow, that focal was assigned to the next open time slot; a replacement focal was selected from a randomly ordered list of focal individuals. Once all focal individuals had been observed once, or had been unavailable for both an initial and a re-assigned follow, a new randomly ordered list was created and focals were again assigned to randomly scheduled observation periods.

Families consented to allow open access to their homes and their children for the duration of the study, with the understanding that they were free to ask for privacy or an end to the observation period at any time they deem necessary. Since homes in Fiji are generally left open to visitors throughout the waking hours, this was not especially unusual, except that it was necessary to explain that observation periods were not social visits. (Without this explanation, every observation period would have been in danger of becoming an invitation for tea, and the observer would have become quite fat, but would not have collected any data). None of the participants or their families requested to terminate a follow early, though follows sometimes ended early when a child fell asleep during observation.

In addition to behavior, I recorded other individuals present, as well as activity and location both at the start of each follow, and *ad hoc* as it changed throughout the follow. Activity blocks function to keep track of the context in which teaching behaviors occurred, at the same resolution as a time allocation study (see Table 3-2 for list of activities coded). The activity blocks do not necessarily correspond to what the teaching was "about" or what was being taught. This is because, under the framework adopted here and explained in Kline (*in prep,* Chapter 2), teaching is not tied to an activity or particular context, but is instead a set of behaviors that may address social learning problems (see section on *Ethogram Design*, below). Similarly, because humans are capable of teaching abstract ideas through verbal communication, there is no way to identify discrete teaching opportunities as a baseline against which to compare the rates of teaching behavior. (See discussion for how this might be achieved experimentally). Others were considered "present" for a follow if they were within vocal range without yelling (about 15 ft), since pilot observations showed that people in the village often interact vocally through house walls and when otherwise not visible, and because yelling to communicate at a distance is prohibited by village rules of conduct in Fiji. Sleeping individuals were not coded as "present."

99

I recorded observations using a system of shorthand codes based on the ethogram as well as identification numbers for individuals, using a Psion Workabout Pro handheld computer. Participant data on age, education, and kinship data were collected during demographic interviews prior to the start of this study. Age difference is calculated as the potential teacher's age minus the focal child's age. Reported genealogical kinship data were used to calculate relatedness coefficients using Hagen's (n.d.) Descent software (see Hagen [n.d.] for the URL). These data were collected initially through the mapping of a kinship tree with knowledgeable informants in each village (typically older women). Data were then checked during demographic interviews in the villages, where one or more participants in each household provided information about the identity of the parents of household members. These were checked against the initial genealogical diagram, and discrepancies were worked out through subsequent informal interviews with those individuals whose descent was not yet clear. In one of the villages, children sometimes attended preschool in the morning. I conducted follows during some of these classes (n=17). The follows conducted in the formal classroom setting are excluded from these analyses. In the following analyses, "teacher" or "potential teacher" does not refer to professional or paid teachers, but rather to any non-focal with whom the focal is observed to be present, and who may (or may not) teach the focal.

Ethogram Design

The design of the ethogram is based on a theoretical framework of teaching types, distinguishing between teaching that facilitates learning by promoting (a) pupil access or (b) pupil attention (see Kline *in prep,* Chapter 2). Teaching types can then be divide according to which of these problems they address for a social learner. Those that promote pupil access to relevant stimuli include:

1. Teaching by social tolerance: in which a pupil attends to relevant stimuli but lacks access to it, because it depends on close and intrusive observation of a conspecific's behavior. In teaching by social tolerance, the teacher allows pupil intrusion, granting the pupil access for close observation. This category does not include cases when proximity is maintained by the teacher, because this behavior addresses the alternate problem of facilitating or at least potentiating the pupil's interest, rather than making access possible to an already attentive pupil.

2. Teaching by opportunity provisioning: in which a pupil attends to relevant stimuli but lacks access to it because it is difficult or dangerous for the pupil to explore independently, without modification. The teacher facilitates learning by providing a less dangerous or less difficult opportunity for pupil to access it.

Teaching types that promote pupil attention to relevant stimuli include:

3. Teaching by evaluative feedback: in which a pupil has access to a behavior or stimulus but does not attend to relevant feedback. The teacher facilitates learning by providing additional positive or negative reinforcement of a pupil's behavior.

4. Teaching by social or local enhancement: in which a pupil has access to a stimulus but lacks attention towards it. The teacher facilitates learning by promoting the pupil's attention toward that stimulus. This could include cases where a teacher establishes and maintains close proximity with the pupil, if such behavior was accompanied by other attention-directing behaviors.

Finally, teaching may promote both pupil attention and pupil access, when both are otherwise lacking:

5. *Direct active teaching*: in which the pupil lacks both access and attention toward a relevant stimulus. The teacher facilitates learning by directing the pupil's attention, and making relevant aspects of the stimulus accessible (whether through making their own actions observable, or making the stimulus less difficult or dangerous to access). This entails defining the boundaries of what is to be learned, and can include but is not limited to direct abstract communication.

The ethogram was developed based on this framework and on approximately 40 hours of video recorded focal follows of children in the first village, conducted during 5 months of fieldwork during 2008-09. For each type of teaching—direct active teaching, teaching by opportunity provisioning, teaching by social tolerance, teaching by social or local enhancement, and teaching by evaluative feedback—I identified theoretically important behavioral indicators of each teaching type. Some of these indicators were already identified in the literature as behavioral markers of teaching in general—for example, ostensive cues like eye gaze, changes in speech prosody, actions punctuated by gesture, and modified task speed or structure (see Tomasello 1993, Gergely et al 2007). The innovation of this ethogram is not simply to identify teaching behaviorally, but to distinguish between a range of teaching behaviors as they apply to learning problems. For a theoretical motivation of the teaching types used here, see Kline (*in prep, Chapter 2*). That chapter also covers the theoretical basis for considering opportunity provisioning and direct active teaching "high effort" as compared to other, lower-effort teaching types: the behaviors required for direct active teaching and opportunity provisioning are less compatible with teachers' ongoing behaviors, and are more likely to require an interruption of the teacher's behavior at some cost. For a detailed outline of the teaching types along with

behavioral indicators and descriptions, see Table 3-1. The ethogram as presented here was tested for feasibility by coding pilot video follows. The video follows also allowed me to practice coding prior to conducting focal follows.

TEACHING TYPE	
behavioral indicator	coding rule description
TEACHING VIA SOCIAL TOLERANCE*	
intrusive touch	Focal (F) touches actor or stimulus such that actor's behavior is altered.
close proximity	F is within F's arm length from an actor, and attends to actor at that time (not proximity alone).
close follow	F maintains proximity with an actor when the actor is moving away.
*Excluded from this set of codes is mutual close social contact or interaction. *Tolerance* is established when an actor does not force the focal to stop or to leave following intrusive behaviors.	
TEACHING VIA EVALUATIVE FEEDBACK	
+/- verbal feedback	Actor gives positive or negative verbal appraisal of F's behavior, in F's presence.
+/- consequences	Actor creates positive or negative consequences for F. Includes physical punishment or reward, or verbal description of promised punishment or reward.
TEACHING VIA ENHANCEMENT	
emphasize	Actor slows or exaggerates movements during observation by F
direct attention	Actor directs F's attention toward a person, location, or object, verbally or through gesture.
TEACHING VIA OPPORTUNITY PROVISIONING	
actor-prompted behavior	F undertaking an action or behavior after being commanded to do so by another actor.
Actor-assisted behavior	F undertaking an action or behavior made possible by another actor's help.
DIRECT ACTIVE TEACHING	

abstract communication	Actor gives a verbal explanation or states abstract information to F –including the statement of rules and what is "taboo" behavior.
demonstration	Actor performs behavior or action conditioned on F's attention; may follow a request from F, or the Actor may first manipulate F's attention.

Table 3-1. This table provides names and definitions of each of the five proposed teaching types, followed by categories of behavioral indicators and descriptions of the coding rules used to record these behaviors during focal follows.

Coding Teaching Events

I calculated the average number of teaching events for each teaching behavior, per activity block for a given follow period. A follow may include a minimum of one activity block, but some follows included up to five different activity blocks (see Table 3-2 for list of coded activities). For each activity block, "teachers" were coded as either performing or not performing each of the five teaching types, after the conclusion of the follow, and based only on the recorded behaviors stipulated in the ethogram. It should be noted that teaching within an activity block can not be equated with teaching something about that activity. (For example, a teacher might point to a person passing by and provide the focal with an appropriate kin term, during the activity of cleaning the house). If a given teacher repeated a teaching type within a block (for instance, repeated negative evaluative feedback towards a focal), this would be coded as a single teaching event. As a result, the maximum number of teaching behaviors for a particular "teacher" per activity block is five. Since each potential teacher's total was tallied separately, the total possible teaching events per activity block is five times the number of others present. This estimate of the number of teaching behaviors controls for the fact that some teaching behaviors are typically repetitive (such as positive verbal feedback), while others are not, or may be enduring states (such as teaching by ongoing social tolerance) rather than iterative behaviors. It is conservative in the sense that multiple unrelated teaching events could happen during a single activity block and would only be counted once, and in that teaching behaviors that happen during two activity

blocks are unlikely to be related because a change in activity is usually associated with a change in location or attention for involved actors.

Results

This study sought to test several predictions about the form and function of teaching. First, evolutionary theory on teaching predicts that teaching should be relatively common in humans, including non-Western societies. The data support the idea that teaching is relatively common (see Figure 3-1), with teaching via opportunity provisioning being most rare (n = 0.047 events per activity block, or 1 event per 25 activity blocks), and teaching via evaluative feedback most common (n = 0.517 events per activity block, or 1 event per 2 activity blocks). When all teaching types are taken together, there are 0.896 teaching events on average per each activity block, or about 9 events for every 10 activity blocks. Across all activity blocks (n = 345), 78 per cent included at least one teaching event.

ACTIVITY CATEGORY	INCLUDED ACTIVITIES:
FOOD	*Eating, suckling, reef foraging, land foraging, fishing, farming, cooking, food processing, nut-cracking*
MANUFACTURING	*Creating or repairing artifacts, getting materials to do so, processing materials for artifact repair or creation*
HOUSEWORK	*Cleaning, fetching household items (food, water, belongings), laundry, dishes, other chores in household, chores outside household*
SOCIAL	*Giving/receiving care (with codes for specific types), attending school, attending church or other ritual gathering, group recreation including games, storytelling, other socializing*
PLAY	*Playing at a task, playing "grown-up," playing with natural environment, playing at a ritual, playing with an artifact*
IDLE	*Idle due to illness, doing nothing, listening to the radio, watching television (never observed), sleeping*
AWAY	*Away at school, away at a social gathering outside of the village, away or unavailable*

Table 3-2. This table lists activity codes. While behaviors were coded continuously across all activities, in data analysis a given teaching type was only counted once per teacher per activity block. If the focal child was *Away* or *Idle/sleeping*, the follow was terminated and is excluded

from the current analyses. Each individual activity listed in the right-hand column was coded separately. They are pooled by category here for ease of presentation.
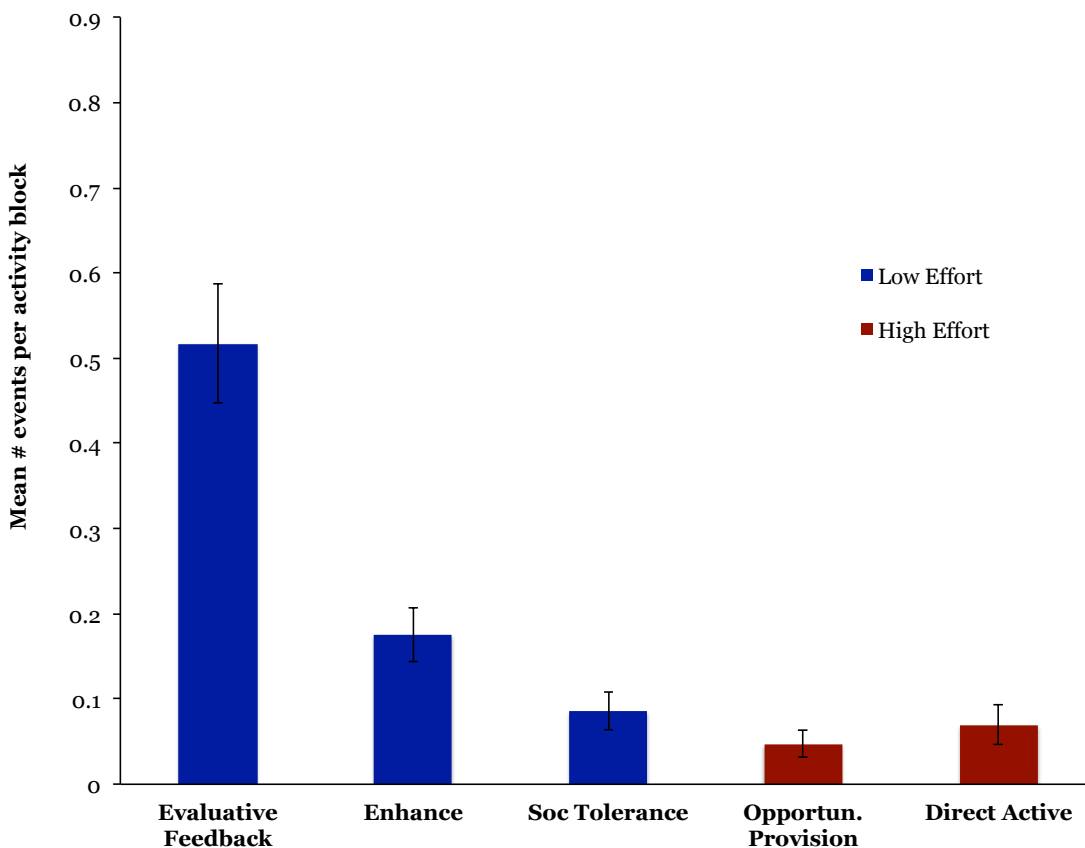
Figure 3-1. This figure shows the average number of teaching events of each type of teaching per activity block, when the number of possible teaching events is limited to one per teacher per teaching type, for each activity block in the sample. Error bars indicate 95% confidence intervals around the means.

A second prediction is that teaching types which require high levels of teaching effort will be less common than those that require lower teaching effort, where opportunity provisioning and direct active teaching are theorized to be higher effort because the behaviors they entail are likely to require that a teacher stops his or her own ongoing behavior (see Kline *in prep,* Chapter 2). Teaching by opportunity provisioning and direct active teaching are theorized to be higher effort, because they require more time and attention from a teacher, and may be more disruptive to a teacher's other goals and behavior (see Kline *in prep*, Chapter 2). This prediction is

supported by a paired samples t-test of the difference between the mean numbers of low-effort teaching events and high-effort teaching events, per activity block. The mean number of low-effort teaching types per activity block (mean = 0.694) is significantly greater than the mean number of high-effort teaching types per activity block (mean = 0.117, $p < 0.000$, n = 1009 dyads). This test did not include teaching by social tolerance, because teaching by social tolerance is always initiated first by the pupil, and the tolerance rate for focals' interference was 100%--on no occasion did an adult reject a focal's attempt at close observation coupled with interference by touching, hovering, or close following (see Table 3-1 for explanation of the behavioral indicators of teaching types). Teachers did sometimes tell children to stop or to leave, but focals never obeyed, and no teacher persisted to the point where the focal altered his/her behavior. This suggests that pupil behavior, rather than teacher behavior, drives the frequency of teaching by social tolerance—such that teaching effort should not be predictive of the frequency of teaching by social tolerance.

Since teaching imposes costs on a teacher (including but not limited to teaching effort), and those costs can only be recouped by the pupils' gains in learning, it follows that relatedness should predict the frequency of teaching for a particular teacher/pupil dyad (see Kline *in prep,* Chapter 2 for thorough discussion). These data show that teacher/pupil dyad relatedness does predict rates of teaching for dyads, even when controlling for the teacher's years of education, teacher/pupil dyadic age difference, and the number of activity blocks during the focal's observation periods that the potential teacher was present within vocal range, or about 15 feet ("co-presence"). Data were analyzed by teacher/pupil dyad, using linear poisson regressions because the distribution of teaching events and the distribution of potential teacher/pupil co-presence are both negatively skewed. The mode number of teaching events per dyad was zero, and the mode number of times co-present per dyad was one. Dyads who were never observed together during a focal's observation period are excluded from analyses. For ease of comparison,

I standardized all independent variables prior to analysis using the *std* function in Stata to calculate z-scores.

I used a multivariate poisson regression model to test the effect of teacher/pupil dyadic relatedness, co-presence, teacher education level, and teacher/pupil dyadic age difference on the prevalence of teaching, where teaching is measured as the total number of instances across all teaching types for a given dyad and activity block. I found that the number of teaching events per dyad is predicted by dyad relatedness (coef. = 0.517, p < 0.000), dyad co-presence (coef = 0.272, p < 0.000), and dyad age difference (coef = 0.123, p < 0.006; see Table 3-3, Model 1). This demonstrates that relatedness has an effect on teaching rates even when the model controls for the fact that closely related individuals spend much more time together. Likewise, dyads that spend more time together (higher co-presence) have higher rates of teaching, independent of how closely related they are. Teacher's level of education has no effect on the number of teaching events per dyad (coef = .042, p <0.329). These results do not change qualitatively when I use clustering to control either for teacher identity or focal/pupil identity. The effect of age is no longer significant when results are clustered by teacher (p < .082 ; see Table 3-3, Model 2). The results are also qualitatively similar using teacher age, rather than age difference. In the same model substituting pupil age for teacher age or age difference, there is an effect of education (coef = 0.136, p < 0.000) and no effect for pupil age (coef = 0.039, p < 0.450). This suggests that teacher age is responsible for the education effect in this alternate model—older individuals are more likely to teach, and they are also more likely to have a higher number of years of schooling. Data were dropped from these analysis for dyads for which the teacher's age or relatedness to the pupil were unknown, such that all models in Table 3 include n = 967 observations.

	Coef	SE	*p*	95% Conf. Interval	
MODEL 1: NO CLUSTERING					
all teaching					
relatedness	0.517	0.035	0.000	0.449	0.585
co-presence	0.272	0.015	0.000	0.243	0.301
education	0.042	0.043	0.329	-0.042	0.126
age difference	0.123	0.044	0.006	0.036	0.210
constant	-0.364	0.040	0.000	-0.443	-0.285
MODEL 2: CLUSTERED BY TEACHER IDENTITY, 237 CLUSTERS					
all teaching					
relatedness	0.517	0.078	0.000	0.364	0.670
co-presence	0.272	0.058	0.000	0.159	0.386
education	0.042	0.074	0.572	-0.104	0.188
age difference	0.123	0.071	0.082	-0.015	0.262
constant	-0.364	0.078	0.000	-0.518	-0.210
MODEL 3: CLUSTERED BY FOCAL IDENTITY, 41 CLUSTERS					
all teaching					
relatedness	0.517	0.062	0.000	0.396	0.683
co-presence	0.272	0.065	0.000	0.145	0.400
education	0.042	0.058	0.471	-0.072	0.156
age difference	0.123	0.055	0.024	0.016	0.230
constant	-0.364	0.067	0.000	-0.496	-0.232
MODEL 4: NO CLUSTERING, VILLAGE EFFECT					
all teaching					
relatedness	0.485	0.035	0.000	0.415	0.554
co-presence	0.331	0.018	0.000	0.296	0.367
education	0.144	0.043	0.305	-0.041	0.129
age difference	0.129	0.044	0.003	0.043	0.215
village	0.646	0.105	0.000	0.440	0.815
constant	-.926	0.103	0.000	-1.128	-0.724
MODEL 5: HIGH EFFORT TEACHING					
high effort					
relatedness	0.737	0.097	0.000	0.547	0.926
co-presence	0.209	0.042	0.000	0.126	0.291
education	0.155	0.116	0.185	-0.074	0.383
age difference	0.363	0.117	0.002	0.135	0.592
constant	-2.640	0.134	0.000	-2.902	-2.378
MODEL 6: LOW EFFORT TEACHING					
low effort					
relatedness	0.481	0.039	0.000	0.404	0.559
co-presence	0.276	0.017	0.000	0.242	0.310
education	0.011	0.050	0.821	-0.086	0.108
age difference	0.072	0.052	0.162	-0.029	0.173
constant	-0.581	0.045	0.000	-0.668	-0.493

Table 3-3. Models 1-3 show the results of poisson regression models predicting the frequency of teaching for a dyad from dyad relatedness, dyad co-presence, teacher's level of education, and dyad age difference (Pseudo R2 = 0.2685). Model 4 adds a dummy variable for village (Pseudo R2 = 0.2787). Model 5 tests the independent variables for high effort teaching only (Pseudo R2 = 0.2313) and Model 6 tests the independent variables for low effort teaching only (Pseudo R2 = 0.2002). For all models, n = 967 dyads, made up of 41 focals and 237 potential teachers.

Teaching type effects

Using the same poisson regression models to predict rates of high-effort teaching and low-effort teaching separately (see Table 3-3, Models 4 and 5 respectively), I found that the effects of relatedness and teacher/pupil dyad age difference are greater for high-effort teaching than for low-effort teaching; for low-effort teaching, the age difference effect is not statistically significant.

Village effects

The focal follow data were collected in two villages. Based on a two-sample t-test with equal variances, there is no statistically significant difference between the mean number of teaching events per activity block across villages (difference = 0.172, p < 0.154). However, when a dummy variable for village is included in the poisson regression model above, residence in the second village positively predicts the number of teaching events per dyad (see Table 3-3, Model 4). Observed dyads in the first village are significantly more closely related (mean r = 0.134) than dyads that are co-present in the second village (mean r = 0.089) based on a two-sample ttest (p < 0.000). This is consistent with the overall effect of relatedness on teaching events, and with the greater mean number of teaching events per activity block in the first village. It does not explain why there is more teaching in the second village, when relatedness and presence are controlled for.

Discussion

Based on quantitative focal follow data with young children in Fiji, this paper shows that teaching is neither absent nor rare in children's day to day lives – in fact it is ubiquitous, occurring on average almost once during every activity block within a follow. The data also show that teaching types hypothesized to require low teaching effort are more common than the types hypothesized to require high teaching effort. Further, the results indicate that relatedness and

age difference have stronger effects on the prevalence of high effort teaching types than on low effort teaching types. This makes sense from an evolutionary standpoint in that the tradeoffs are greater when the costs of teaching effort are higher. Future studies should use measures of actual teaching effort to test whether direct active teaching and teaching via opportunity provisioning require greater teaching effort, as theorized. Data on teaching effort could also establish a direct link between teaching effort and the frequency of specific teaching behaviors, within the types as laid out in the ethogram above (see also Kline *in prep,* Chapter 2). Finally, these data show that close relatedness between a teacher/pupil dyad predicts greater rates of teaching. For the age group studied (6y.o. and younger) this could be characterized as a type of childcare, and—if demonstrably costly—even as a type of investment. There is also a positive effect of age difference between potential teacher and pupil on the rate of teaching. There was no effect of a teacher's level of education on rate of teaching, when teacher's age was controlled for. This suggests that teaching in these villages is not simply an effect of being acculturated to Western-style ways of learning or parenting, or, alternatively, a result of learning the "technology" of teaching (Heyes, 2012). This finding is reconcilable with early ethnography suggesting the absence of teaching in Fijian societies in that ethnographers were looking only at a subset of the teaching behaviors that I have classified as direct active teaching—namely, abstract verbal instruction. One strength of the new taxonomy of teaching types used here is that it maintains continuity, tracking a number of "teaching" behaviors separately to allow comparison across existing definitions. Direct active teaching is rare based on these data, and might not be observed by an anthropologist using participant observation rather than a structured focal follow method. In addition, most early ethnographers in the Pacific (and elsewhere) were male. Fijian society is strongly gendered and would have been even more so in the past (see e.g., Hocart 1929, Sahlins 1962), such that these male ethnographers would not have had full access to the daily lives of young children and their mothers. The strongest claims about the absence of teaching outside the west are based on readings of existing ethnographies

(e.g., Lancy & Grove 2010), so are subject to these data collection issues as well. (See also Kline, *in prep;* Chapter 2 for a reorganization of some of the examples used by Lancy & Grove into the new taxonomy).

The data have some limitations that lead to suggestions for future research. These data are not sufficient to study the question of cross-cultural comparisons in detail—for that it will be necessary to conduct a broader cross-cultural comparative study using comparable methods. Such a study might look at societies that traditionally vary in the amount of time children spend embedded in adult activities, or may compare across villages in a single society that vary in terms of market integration. These data demonstrate a between-village difference in teaching rates that cannot be explained by the individual or dyadic differences that explain variation in the prevalence of teaching at the dyadic level. An interesting question going forward is whether there is village-level or society-level socioecological variables that explain this kind of difference. Further, there may be cross-cultural variation in the use of different teaching types that was not captured by this study, because it only compares samples from within Fiji, and two villages that are historically quite similar and that are still interconnected through kinship and other social ties.

Ethnographers may have identified at least one prospective cross-cultural difference, which is the relative prevalence and importance of direct active teaching. The present research falsifies the strong claim that teaching is absent in Non-Western societies, but cannot address relative frequency across societies. One possibility is that there is little cross-cultural variation in the prevalence of teaching, and that perhaps existing ethnographic accounts are the result of culture-dependent definitions of what constitutes "teaching," or of an ethnographic bias to highlight differences between societies, rather than similarities. Holding this aside, another possibility is that high-effort teaching between *unrelated* individuals is only relatively common where social institutions exist to compensate teachers, whether through apprenticeships,

prestige, or (as in present-day Western societies) through direct compensation to teachers. Noisy transmission processes can result in the loss of cultural information, particularly in small isolated populations (Henrich 2004, 2006; Powell et al. 2009; Kline & Boyd 2010, Derex et al. 2013, Muthukrishna et al. 2013). If teaching enables faithful cultural transmission, then it may also be the case that social institutions supporting teaching dampen the effects of such drift-like processes.

Social institutions may offset individual costs of teaching, but do not provide an ultimate explanation (or hypothesis) about cross-cultural variation in teaching behavior. For an ultimate explanation, researchers should look to socio-ecological variation in the types of skills and knowledge being learned, and the opportunities that children have to learn them, across different societies. To take the present study site as an example, children in Fijian villages spend much of their time either in mixed age and sex playgroups, or following along with adults during the adults' daily subsistence work, chores, and social visits. In this social setting, children may gain a great deal of background knowledge about what it takes to be a successful member of society—from technical skills like scaling a fish or the stages of mat-weaving, to social skills such as how to address one's elders with appropriate deference and the inappropriateness of expressing anger openly. This level of background knowledge may put children at an advantage as they observe and learn socially, so that high-effort types of teaching may not be necessary—in that they would not improve the speed or fidelity of a child's learning in many areas of life. This is consistent with findings that Fijian adults are more likely to elect "teaching" in general as a mode of transmission for tasks that are high in skill difficulty (Kline et al. 2013), suggesting that teachers may only bother to teach when pupils would otherwise have difficulty learning.

In Western countries and other societies where children are likely to spend their days at play while their parents are at work, children may have less of an opportunity to observe and experiment in typically "adult" domains. As a result, children may lack the type of casually

learned background knowledge that is typically learned through participant observation by young children in small-scale societies. As a result, children in Western societies might more frequently be in situations where they lack both attention and access to relevant information, such that direct active teaching becomes a more important tool for social learning. This is even more likely to be true where many of the skills that children are expected to eventually learn are causally opaque—such as the rules for safe driving, or basic mathematics, or how to work complex machines like televisions, cell phones, and refrigerators. Again, this is consistent with the finding that high-skill tasks learned later in life by Fijians—such as traditional medicine or weaving—are more likely to be associated with "teaching" as a means of learning (Kline et al. 2013).

Finally, the present data do not directly address the question of what is being taught, mainly because the activity codes specify contexts during which teaching happened, not the content of the teaching. Humans can use language to teach abstract concepts verbally, and out of context. This means that, at least for direct active teaching, teaching can happen at any time and place. This factor makes it difficult to establish any sort of baseline for when teaching might be useful. At its most extreme, time and energy are the only real limits on how much teaching could happen in a hypothetical world. Future studies might better address this by using the ethogram presented here along with methods to determine what it is that is being taught, or might attempt to experimentally manipulate the "need" for teaching to better understand how context and the presence of the learning problems discussed above (see also Kline *in prep*, Chapter 2) might influence teaching rates.

Conclusion

These findings can change the way teaching is studied in humans. In the past, anthropologists have used a culture-bound concept of teaching—often without explicit definition—and used

participant observation to make qualitative generalizations about the cross-cultural prevalence

of teaching. This study, using a novel theoretical framework and systematic sampling, found that

while subtle, low-effort forms of teaching are relatively common, teaching types like direct active

teaching are less common. This suggests that while anthropologists may be correct in describing

a single form of teaching—most similar to direct active teaching—as rare, they have neglected to

study the more cross-culturally common forms of teaching discussed above. The data presented

here make it clear that the study of cross-cultural variation in teaching ought to focus on the

relative importance of different types of teaching, rather than on the wholesale presence or

absence of teaching as a general phenomenon.

References

Altmann, J. Observational study of behavior: sampling methods. *Behavior,* 49:227-267.

Arno, A. Disentangling Indirectly: The Joking Debate in Fijian Social Control. In: Watson-Gegeo,
K.A. and White, G.M (Eds.) *Disentangling, Conflict Discourse in Pacific Societies.*
Stanford U Press, Stanford. 1990.

Bock, J. (2002). Learning, life history, and productivity. *Human Nature*, *13*(2), 161–197.

Borofsky, R. 1987. *Making History: Pukapukan and anthropological constructions of
knowledge*. Cambridge: Cambridge University Press.

Brison, K. T. 2007. Imagining Modernity in Rural Fiji. *Ethnology* 42:335-348.

Boyd, R., & Richerson, P. J. (1985). *Culture and the Evolutionary Process*. University of Chicago
Press.

Boyd, R., Richerson, P. J., & Henrich, J. (2011). Colloquium Paper: The cultural niche: Why
social learning is essential for human adaptation. *Proceedings of the National Academy
of Sciences*, *108*(Supplement_2), 10918–10925. doi:10.1073/pnas.1100290108

Caro, T., & Hauser, M. (1992). Is there teaching in nonhuman animals? *Quarterly Review of
Biology*, *67*(2), 24.

Cavalli-Sforza, L. L. (1981). *Cultural Transmission and Evolution*. Princeton University Press.

Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences*, *13*(4), 148–153.

Csibra, G., & Gergely, G. (2011). Natural pedagogy as evolutionary adaptation. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *366*(1567), 1149–1157. doi:10.1098/rstb.2010.0319

Dakuidreketi, M. R. (2004). *Contexts of Science Teaching and Learning in Fiji Primary Schools*. Dissertation Thesis, University of the South Pacific.

Dean, L. G., Kendal, R. L., Schapiro, S. J., Thierry B, & Laland, K. N. (2012). Identification of the Social and Cognitive Processes Underlying Human Cumulative Culture. *Science*, *335*(6072), 1114–1118. doi:10.1126/science.1213969

Derex, M., Beugin, M.-P., Godelle, B., & Raymond, M. (2014). Experimental evidence for the influence of group size on cultural complexity. *Nature*, *503*(7476), 389–391. doi:10.1038/nature12774

Hagen, E. n.d. Descent [computer software]. http://code.google.com/p/descent/ (accessed November 17, 2013).

Harris, M. (2001). *Cultural Materialism*. Rowman Altamira.

Henrich, J. (2004). Demography and cultural evolution: how adaptive cultural processes can produce maladaptive losses-the Tasmanian case. *American Antiquity*, *69*(2), 197–214.

Henrich, J., & Broesch, J. (2011a). On the nature of cultural transmission networks: evidence from Fijian villages for adaptive learning biases. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *366*(1567), 1139–1148. doi:10.1098/rstb.2010.0323

Henrich, J., & Broesch, J. (2011b). Electronic Supplementary Information (ESM) for On the Nature of Cultural Transmission Networks. *Philosophical Transactions of the Royal Society B*, (00), 1–10.

Henrich, J., & Mcelreath, R. (2003). The evolution of cultural evolution. *Evolutionary*

Anthropology Issues News and Reviews, *12*(3), 123–135. doi:10.1002/(ISSN)1520-6505

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*(2-3), 61–83. doi:10.1017/S0140525X0999152X

Hewlett, B. S., & Lamb, M. E. (2005). *Hunter-gatherer Childhoods*. Transaction Publishers.

Hewlett, B. S., Fouts, H. N., Boyette, A. H., & Hewlett, B. L. (2011). Social learning among Congo Basin hunter-gatherers. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *366*(1567), 1168–1178. doi:10.1098/rstb.2010.0373

Heyes, C. (2012). Grist and mills: on the cultural origins of cultural learning. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1599), 2181–2191. doi:10.1098/rstb.2012.0120

Hocart, A.M. *Lau Islands, Fiji.* Honolulu: Bernice P. Bishop Museum, 1929

Hoppitt, W., Brown, G., Kendal, R., & Rendell, L. (2008). Lessons from animal teaching. *Trends in Ecology & Evolution*.

Kline, M. A., & Boyd, R. (2010). Population size predicts technological complexity in Oceania. *Proceedings of the Royal Society B: Biological Sciences*, 1–17. doi:10.1098/rspb.2010.0452

Kline, M. A., Boyd, R., & Henrich, J. (2013). Teaching and the Life History of Cultural Transmission in Fijian Villages. *Human Nature*, *24*(4), 351–374. doi:10.1007/s12110-013-9180-1

Lancy, D. (2008). Anthropology of childhood: cherubs, chattel, changelings, Cambridge University Press, Cambridge.

Lancy, D. and Grove, M.A. The role of adults in children's learning. (2010). In D. F. Lancy, J. Bock, and S. Gaskins (Eds.), *The Anthropology of Learning in Childhood*. Lanham, MD: AltaMira Press.

Mesoudi, A. (2011). *Cultural evolution: how Darwinian theory can explain human culture and synthesize the social sciences*. University of Chicago Press.

Muthukrishna, M., Shulman, B. W., Vasilescu, V., & Henrich, J. (2013). Sociality influences cultural complexity. *Proceedings of the Royal Society B: Biological Sciences*, *281*(1774), 20132511–20132511. doi:10.1016/j.tics.2011.03.003

Nabobo-Baba, U. (2006). *Knowing & Learning: An Indigenous Fijian Approach*. Suva: Institute of Pacific Studies Press.

Nayacakalou, R. *Leadership in Fiji*. Oxford U Press, Melbourne, 1975

Paradise, R., & Rogoff, B. (2009). Side by Side: Learning by Observing and Pitching In. *Ethos*, *37*(1), 102–138. doi:10.1111/j.1548-1352.2009.01033.x

Ochs, E., B.B. Schieffelin. Language Acquisition and Socialization. In: RA Shweder and RA Levine (Eds), *Culture Theory: Essays on Mind, Self, and Emotion*. Cambridge U Press, Cambridge, 1984.

Powell, A., Shennan, S., & Thomas, M. G. (2009). Late Pleistocene Demography and the Appearance of Modern Human Behavior. *Science*, *324*(5932), 1298–1301. doi:10.1126/science.1170165

Ravuvu, A. *The Fijian Way*. U South Pacific Press, Suva, 1983.

Ritchie, JB, JE Ritchie. *Growing up in Polynesia*. Little Hampton Book Svc, 1979

Rogoff, B., Paradise, R., Arauz, R., Correa-Chávez, M., & Angelillo, C. (2003). Firsthand learning through intent participation. *Annual Review of Psychology*, *54*(1), 175–203.

Sperber, D., & Wilson, D. (1995). *Relevance*. Wiley-Blackwell.

Thornton, A., & McAuliffe, K. (2012). Teaching can teach us a lot. *Animal Behaviour*, *83*(4), e6–e9. doi:10.1016/j.anbehav.2012.01.029

Tomasello M, Kruger AC, & Ratner HH. (1993). Cultural learning. *Behavioral and Brain Sciences*, *16*, 450.

Veramu, J. 1992. *Let's Do it Our Way: A Case Study of Participatory education in a Rural Fijian School and Community*. Suva: Institute of Pacific Studies Press.