Culture-gene coevolutionary theory and children's selective social learning

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Abstract

Human cognition is unique in the degree to which it is shaped by social learning and cumulative cultural evolution. To learn efficiently children cannot just passively absorb all the information others provide, they need to be sensitive to when, if, and who is a good source of information. Several lines of theoretical and empirical inquiry are probing the cognitive mechanisms that underlie humans' flair for cultural learning. Among these, Culture-Gene Coevolutionary (CGC) theory focuses on the evolutionary dynamics our emerging cultural species faced and the learning biases that likely resulted from these selection pressures. CGC theory specifies a suite of hypotheses about which learning biases most effectively extract adaptive information. Here we review the intersection between these and developmental psychologists' recent empirical insights into children's social learning. We focus on two types of biases: 'relative model biases' which help learners identify which models are likely to possess information that is applicable for them given the particular social groups to which they belong; and 'absolute model biases' which help learners select those models most likely to possess objectively better information. In light of recent developmental findings we advocate CGC theory as a useful framework for organizing, understanding, and generating research on children's selective social learning.

Introduction

Humans have an unusual ability to socially learn complex, arbitrary information – we learn from others how to build kayaks, write papers and fold them into aeroplanes. These social learning capacities made possible the accumulation of complex technologies we now rely on and likely underlie our capacity for large-scale cooperation (Chudek & Henrich, 2011). Evolutionary and developmental insights into children's social learning have great potential for cross-fertilisation. Evolutionary theories can generate and integrate developmental hypotheses, while developmental investigations test and inform evolutionary theory. However this intersection is also rich with potential for spurious storytelling. Developing *good* accounts of the evolution of the development of social learning is a real challenge.

Why does our social cognition develop as it does? Why do young minds possess the specific cognitive mechanisms that they do, not some other set? What's hard about answering these questions is that it's so easy. For any aspect of social cognition, one can easily generate tens of plausible evolutionary stories about how it helped our ancestors survive (really, try it with a friend). Unfortunately the meagre traces left by the past make most evolutionary stories impossible to either verify or refute.

To generate verifiable ultimate hypotheses theorists face the much harder challenge of deducing past adaptations *a priori*, without reference to modern social cognition. This can sometimes be accomplished by starting from physical evidence of our species' history and reasoning forward by way of explicit, typically mathematical, arguments grounded strictly in evolutionary theory. The resulting ultimate theories can generate precise, falsifiable, a priori predictions about modern cognition. Though they remain hard to definitively verify as explanations for any single social-cognitive-developmental effect, these hypotheses are tested by their ability to integrate a broad spectrum of evidence under the umbrella of very few assumptions about the ancient past. For example, evolutionary models of optimal conformity rates for social learners (e.g., Boyd & Richerson, 1985, among others) agree not only with human behaviour (Efferson, Lalive, Richerson, McElreath, & Lubell, 2008; Toelch, Bruce, Meeus, & Reader, 2010) but also social learning in rats (Galef & Whiskin, 2008) and fish (Pike & Laland, 2010).

Here we review Culture-Gene Coevolutionary (CGC) theory (e.g., Boyd & Richerson, 1985; Mesoudi, 2009; Richerson & Boyd, 2005) which, taking just this tack, predicted in advance several recent findings on the development of social cognition. We briefly describe the evolutionary dynamics that ground CGC; then review the predictions that these dynamics entail for the development of social cognition and their fit to recent findings.

Evolved Cumulative Cultural Learning and the Development of Social Cognition

Though some cultural learning – that is, the transmission of behaviours from one individual to another by observation – is present in other species, only humans learn faithfully enough that culture accumulates and gradually generates complex behaviours, such as baking and origami. This, along with other evidence (e.g., see Richerson & Boyd, 2005), suggests that sophisticated, metabolically expensive brains capable of cumulative cultural learning are selected against (i.e., genetic mutants with more sophisticated brains have fewer surviving offspring) until a species' cultural repertoire (i.e., the cultural knowhow transmitted between generations) provides a substantial fitness advantage. Once this threshold is passed[1], culture accumulates and its fitness consequences grow exponentially; a positive feedback that generates strong genetic selection for brains better at cultural learning.

Since culture changes much faster than genes, direct genetic adaptations for better cultural learning must exploit cues that reliably distinguish better from worse cultural models across social groups and generations. CGC theorists have outlined several ecological cues that any highly cultural species should exploit. In particular, 'model biases' – features of cultural models (i.e. other individuals) that reliably indicate bearers of better (i.e. more fitness enhancing) cultural knowledge – imply phenotypic predictions about the development of social cognition. These predictions can be divided into two classes: 'relative model biases' help learners identify models possessing knowledge relevant to them (i.e., it applies to their

1. For an account of when and why our ancestors in particular passed this threshold, see (Richerson & Boyd, 2005).

age, sex, social or cultural group), and 'absolute model biases' help identify models whose cultural knowledge is just better (e.g., more accurate or useful).

Next, we'll briefly explain the logic of each prediction and its fit to recent evidence. Some predictions will seem quite obvious to readers fortunate enough to have already studied modern human children, but remember: the test of ultimate theories isn't how well they explain any one effect (that's easy), it's how easily they account for a vast range of modern phenomena, even retrospectively obvious ones, by reasoning forward from an ancestral state where they didn't exist, invoking as few assumptions as possible.

Relative Model Bias: Age

Sometimes different behaviours are fitness enhancing for human juveniles (e.g., acting cute) than for adults (e.g., sexual courtship). Consequently, selection will consistently favour cultural learners who discriminate potential models by age over learners less sensitive to model age; particularly favouring a disposition to learn from 'slightly older' models (Henrich & Gil-White, 2001). Consistent with this simple prediction, young children do seem to assess the age of cultural models: they prefer older models unless they have proven unreliable (Jaswal & Neely, 2006), but younger models in domains relevant to young people (e.g., toys: VanderBorght & Jaswal, 2009); and are more likely to learn preferences (Shutts, Banaji, & Spelke, 2010), and a variety of other behaviours (see Hilmert, Kulik, & Christenfeld, 2006) from similarly aged models.

Relative Model Bias: Self-similarity (including sex)

Sexual and social divisions of labour are common in contemporary foraging societies. Divisions present in ancestral societies would have favoured learners who prefer learning from models who are most 'like them' (e.g. same sex, same social group, etc) (Henrich & Gil-White, 2001; Henrich & McElreath, 2003). Evidence that children preferentially learn from self-similar, particularly same sex models, is decades old (e.g., Rosekrans, 1967; Wolf, 1973) and recent work has shown that they preferentially acquire same-sex models' preferences (Shutts, et al., 2010). Moreover, children (Gottfried & Katz, 1977) and adults (e.g., Hilmert, et al., 2006) seem particularly disposed to learn from those who share their existing beliefs.

Relative Model Bias: Ethnicity (including language and accent)

The use of fitness-neutral cues to distinguish cultural groups (e.g., body markings, accent; sometimes called *ethnicity*) is a natural consequence of cultural learning (McElreath, Boyd, & Richerson, 2003). Another consequence is plentiful 'coordination dilemmas' – situations where it's better to behave like your group-members (e.g. norms, etiquette, morals). Together these lend selective advantage to young learners who prefer learning from their co-ethnics.

Five- to 6-month-olds prefer looking at individuals with familiar accents, 10-month-olds prefer accepting toys from and eating food associated with linguistic co-ethnics, while 5-year-olds prefer them as playmates (Kinzler, Dupoux, & Spelke, 2007; Kinzler, Shutts, DeJesus, & Spelke, 2009; Shutts, Kinzler, McKee, & Spelke, 2009). Four- to 5-year olds preferentially trust novel object functions demonstrated by a native-sounding speaker who speaks only nonsense syllables over a non-native sounding speaker (Kinzler, Corriveau, & Harris, 2010). Five-year-olds also make potent social inductions on the basis of ethnic labels (Diesendruck & HaLevi, 2006).

Absolute Model Bias: Skill

A young mind that can perceive skill[2] differences between potential models can make wiser learning decisions. For instance, young learners might infer the better hunter by who throws further. Termed 'skill-bias', CGC theorists predicted that cultural learners will exploit perceptible skill differences (Henrich & Gil-White, 2001; Henrich & McElreath, 2003).

2. By 'skill' we just mean 'whatever behaviour produces higher fitness on average'.

Recent investigations have repeatedly demonstrated that children who witness obvious skill differences prefer learning novel object labels (e.g., Koenig & Harris, 2005; Scofield & Behrend, 2008) and functions (e.g., Birch, Vauthier, & Bloom, 2008) from more accurate models, even after a one week delay (Corriveau & Harris, 2009b), even when only the more skilled model is a stranger (Corriveau & Harris, 2009a); for a review see Gelman (2009). Besides their names and functions, children also seem sensitive to models' skill at predicting objects' non-obvious causal properties (Sobel & Corriveau, 2010). Young children also prefer learning from more confident cultural models (Birch, Akmal, & Frampton, 2010; Jaswal & Malone, 2007; Sabbagh & Baldwin, 2001), potentially exploiting the model's own assessment of his or her skill.

Absolute Model Bias: Success

Skill differences are often opaque, especially in the limited time learners have to make a decision. For instance, though the relative quality of two adults' diets may be apparent after several years, young learners must choose what to eat for dinner tonight. The cumulative consequences of skill, termed 'success' (e.g. a fat belly, fine ornamentation, good outcomes in life) are often readily apparent, even when the mechanisms that generated them are not (Boyd & Richerson, 1985; Henrich & Gil-White, 2001; Henrich & McElreath, 2003). Interestingly, a sensitivity to cues to success may even explain why both North American (Olson, Banaji, Dweck, & Spelke, 2006) and Japanese (Olson, Dunham, Dweck, Spelke, & Banaji, 2008) 5- to 7-year-olds report liking and judging as nicer individuals who've experienced seemingly random, or at least unexplained, positive outcomes as well as members of groups that experience more positive outcomes.

Absolute Model Bias: Prestige

The trappings of success vary across time and societies: e.g., a fat belly carries different implications now than it did once. However, one feature is reliably shared by quality cultural models everywhere: other learners also prefer to learn from them. Henrich and Gil-White (2001) predicted a cultural species would possess a disposition to prefer learning from whomever others are learning from, termed ‘prestige-bias’.

Young children prefer learning from models who bystanders have previously watched, smiled at and agreed with (Fusaro & Harris, 2008); however such explicit agreement could also cue the models’ ethnicity, her prior accuracy, or how common (rather than accurate) her opinions are. Our own recent work (Chudek, Heller, Birch, & Henrich, in press) specifically tested the unique effects of prestige by demonstrating that children prefer learning from adult models who bystanders have merely preferentially attended to (i.e. no endorsement or positive affect). Moreover, this effect seems domain sensitive – adults watched by bystanders while using tools are preferentially trusted for tool-use techniques but not food preferences.

Overview

Humans are undeniably a highly cultural species. For instance, children trust the testimony of adults over their own perception (Jaswal & Markman, 2007; Topál, Gergely, Miklosi, Erdohegyi, & Csibra, 2008) and imitate adults’ obviously redundant actions (Lyons, Young, & Keil, 2007), even when accuracy is incentivised (Jaswal, 2010). CGC predicts which phenotypes – that is, individuals’ actual judgements and behaviours –are robustly selected for in a species dependent on cultural learning.

Unlike psychological theories that specify mechanistic explanations for particular behavioural phenomena, CGC refers to the set of predictions derived by reasoning about how selective pressures shaped our cultural species. Though one could generate many proximate theories to account for these same effects, CGC is unique in simultaneously predicting this entire broad set of empirical phenomena from a simple core insight. Though many of these predictions rest on subtle mathematical arguments about natural selection, we verbally summarised their logic above and synthesized the developmental evidence they integrate.

CGC reasoning, which unfolded in isolation from developmental research, fits well with recent developmental findings. Far from competing with or contradicting proximate explanations, *a priori* ultimate theories like CGC are consistent with most cognitive mechanisms proposed by developmental psychologists and can compliment and help conceptually organise the diverse findings emerging from developmental investigations of social cognition. They answer a differed kind of question: rather than explaining how cognitive mechanisms influence children's behaviour, they help us understand why these particular mechanisms should exist in the first place. They are also an excellent source of generativity; that is, they suggest previously unconsidered phenomena – such as prestige bias – worthy of empirical study and proximate explanation. We therefore propose CGC theory as a useful framework for organizing and understanding the rapidly emerging mix of developmental insights into children's selective social learning.

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