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An experimental simulation of the “copy-successful-individuals” cultural learning strategy: adaptive landscapes, producer–scrounger dynamics, and informational access costs

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Abstract

An experimental simulation of cultural evolution was conducted using the virtual arrowhead task. Participants designed “virtual arrowheads” and tested them in “virtual hunting environments”, improving their designs through either individual trial-and-error learning or by copying the design of another participant. A previous study using this task [Mesoudi, A., & O’Brien, M. J. (2008). The cultural transmission of Great Basin projectile point technology I: An experimental simulation. *American Antiquity*, 73, 3–28.] found that a cultural learning strategy of “copy-successful-individuals” was significantly more adaptive than individual learning. The present study explored the robustness of this finding using the same task but under different conditions. It was found that (a) individual learning was significantly more adaptive in a unimodal adaptive landscape than in a multimodal adaptive landscape, suggesting that the adaptive advantage of cultural learning would disappear in unimodal environments; (b) the adaptive advantage of copy-successful-individuals was maintained when cultural learning was permitted at regular intervals, despite the increased opportunity for information scroungers to inhibit exploration of the environment, because participants flexibly switched between individual and cultural learning depending on circumstances; (c) allowing participants to set access costs that other participants must pay in order to view their designs severely curtailed the use of cultural learning and especially the copy-successful-individuals strategy.

Keywords: Adaptive landscapes; Copy-successful-individuals; Cultural evolution; Cultural learning; Cultural transmission; Gene-culture coevolution; Indirect bias; Producer–scrounger dynamics; Informational access costs; Prestige bias; Social learning; Virtual arrowhead task

1. Introduction

Over the past 30 years, the field of cultural evolution (or gene culture coevolution/dual inheritance theory) has sought to incorporate culture into evolutionary analyses of human behaviour by treating culture as an evolutionary process that operates in parallel to genetic evolution (Boyd & Richerson, 1985, 2005; Cavalli-Sforza & Feldman, 1981; Henrich & McElreath, 2003; Laland & Brown, 2002; Mesoudi, Whiten, & Laland, 2004, 2006; Richerson & Boyd, 2005). The majority of this work has involved the construction and analysis of formal mathematical models of cultural processes (e.g., Cavalli-Sforza & Feldman, 1981; Boyd & Richerson, 1985, 2005) drawing on the methods of theoretical population genetics. Such models have, for example, explored the conditions under which culture itself would be favoured by genetic evolution (Boyd & Richerson, 1985, 2005), the properties of different modes of cultural transmission, such as vertical, oblique, and horizontal transmission (Cavalli-Sforza & Feldman, 1981), and the origin and consequences of various cultural forces, such as conformity (Henrich & Boyd, 1998) and prestige bias (Henrich & Gil White, 2001).

Mathematical models, however, are only as good as their assumptions, and these assumptions, as well as the models’ predictions, need to be empirically tested. One way of doing this is by using laboratory experiments (Mesoudi, 2007), and

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several studies have recently sought to simulate cultural evolution and cultural transmission in the lab using experimental methods (Baum, Richerson, Efferson, & Paciotti, 2004; Caldwell & Millen, 2008; Efferson, Lalive, Richerson, McElreath, & Lubell, 2008; Kameda & Nakanishi, 2002, 2003; McElreath et al., 2005; Mesoudi & O'Brien, 2008; Mesoudi, Whiten, & Dunbar, 2006). In one of these studies, Mesoudi and O'Brien (2008) experimentally simulated a cultural learning strategy of "copy successful individuals" [see Laland (2004); also resembling Boyd & Richerson's (1985) "indirect bias" or Henrich & Gil-White's (2001) "prestige bias"] using the "virtual arrowhead" experimental task. In this task, participants played a computer game in which they designed a technological artifact (an arrowhead) either by individual trial-and-error learning or by copying successful fellow participants. Mesoudi and O'Brien found that allowing participants to preferentially copy the designs of successful models resulted in significantly improved performance relative to individual learning controls, suggesting that this copy-successful-individuals cultural learning strategy is significantly more adaptive than individual learning.

Here I present a further experiment using the same virtual arrowhead task that is designed to explore the robustness of this earlier finding. Specifically, the present study asks whether the copy-successful-individuals strategy remains adaptive when (a) the shape of the adaptive landscape that determines a design's fitness is changed from multimodal to unimodal, thus making individual learning easier; (b) when cultural learning is permitted at regular intervals throughout the experiment rather than only during the last few trials, thus allowing greater opportunity for the emergence of free-riding information scroungers; and (c) when potential models can set informational access costs that potential learners must pay in order to access the models' information. Before discussing the theoretical basis of these issues, the following section provides more details of the virtual arrowhead experimental task.

2. The virtual arrowhead experimental task

Mesoudi and O'Brien (2008) employed a computer-based experimental task in which participants designed their own virtual arrowheads. [The aim of that study was to simulate a specific archaeological scenario of past cultural evolution proposed by evolutionary archaeologists Bettinger and Eerkens (1999); however, these archaeological details are not directly relevant to the present study and are not discussed further.] Participants are told to imagine themselves as hunters in the distant past and told that they must design an arrowhead that they will then use to go hunting for food. They are told that their hunting success depends on the design of their arrowhead: Some arrowhead designs give higher returns than other arrowhead designs, and it is their task to find the best/optimal arrowhead design for their particular hunting environment.

The participants enter values for five attributes of their arrowhead: length, width, thickness, shape, and color. The first three attributes are continuous, ranging from 1 to 100 arbitrary units, and the last two are discrete, each taking one of four different values. Once the participants have entered values for all five attributes, they can test their design by going on a hunt (trial), during which they are given feedback on the success of their arrowhead design. This feedback is given in calories, ranging from 1 to 1000, which is partly determined by the participants' chosen attribute values via experimenter-set fitness functions. These fitness functions may vary in shape (e.g., unimodal or bimodal: see Section 3.1) or, alternatively, attributes may be neutral (e.g., color) and not affect fitness. This mix of continuous and discrete, functional and neutral attributes is intended to provide a more realistic simulation of cultural (especially technological) evolution compared with previous cultural evolution experiments (e.g., Efferson et al., 2008; Kameda & Nakanishi 2002, 2003; McElreath et al., 2005), which employ a relatively simple task featuring a single dichotomous attribute (e.g., which one of two crops to plant). There is also random error in the feedback, where the feedback displayed to participants was randomly drawn from a normal distribution with a mean of the actual fitness of the participant's arrowhead design and a standard deviation of 5 calories. This small random error makes individual learning somewhat unreliable, which is probably more representative of most real-life learning tasks than an assumption of perfect environmental feedback. During a typical hour-long experiment, the participant plays three seasons of hunting, with each season comprising 30 hunts. There are therefore 30 opportunities to improve one's arrowhead design during each season.

In order to explore the effect of cultural/social learning, participants play the virtual arrowhead game on networked PCs. The experimenter can allow participants to view the arrowhead design of one or more other participants in the same group via the on-screen interface. In Mesoudi and O'Brien (2008), participants in groups of six had to learn individually for the first 25 hunts of each season before being allowed to copy each other during the last five hunts of each season. Specifically, we simulated a copy-successful-individuals cultural learning strategy, in which participants could see the cumulative score of every other participant in their group and choose to copy one of those fellow group members. The strategy followed by the majority of participants was to copy the arrowhead of the participant with the highest score. As shown in Fig. 1A, participants who could employ the copy-successful-individuals cultural learning strategy significantly outperformed individual controls (who did not engage in cultural learning at any time) during the last five hunts when the former were allowed to copy one another.