Integrating Models of Cognition and Culture Will Require a Bit More Math

Accepted commentary on Veissière et al., *Thinking through other minds: A variational approach to cognition and culture,* in press at *Behavioral and Brain Sciences*

Matthew R. Zefferman
Department of Defense Analysis
Naval Postgraduate School
1 University Circle, Monterey, CA 93943 USA
Email: mrzeffer@nps.edu
Web: http://www.zefferman.com

Paul E. Smaldino
Department of Cognitive and Information Sciences
University of California, Merced
5200 N. Lake Rd, Merced, CA 95343 USA
Email: psmaldino@ucmerced.edu
Web: http://smaldino.com/

Abstract: We support the goal to integrate models of culture and cognition. However, we are not convinced that the free energy principal (FEP) and Theory Through Other Minds (TTOM) will be useful in achieving it. There are long traditions of modeling both cultural evolution and cognition. Demonstrating that FEP or TTOM can integrate these models will require a bit more math.

There is a decades-long tradition in which mathematical and computational models of social learning and cultural evolution demonstrate why social learning evolves; when it is useful; why it can be biased towards learning from the majority or from prestigious, successful, or similar individuals; and how learning biases help create the population-level dynamics of cultural change (Boyd & Richerson 1985, Henrich & McElreath 2003, McElreath & Henrich 2007). In turn, an understanding of these population-level dynamics has helped us understand and explain a wide range of phenomena including the origins of human cooperation (Richerson et al. 2016), civilization (Bowles & Gintis 2011), social identity (Smaldino 2019), hipsters (Smaldino and Epstein 2015), warfare (Zefferman & Mathew 2013), sex-biased tool use in dolphins (Zefferman 2016), and environmental sustainability (Waring et al. 2017). This theoretical framework already answers a number of questions Veissière et al. care about.

A criticism of this body of literature is that cultural evolutionary theory does not adequately consider cognition (Heyes 2018). There are indeed questions about cultural evolution and social learning that a better understanding of cognition might help answer. In particular, cultural

evolution likely shapes the sociocultural environments in which the cognitive machinery that facilitates social transmission develops. Learning more about the dynamical interaction between cognitive development and cultural evolution is an important and, until very recently, underappreciated research area (Contreras Kallens et al. 2018; Smaldino & Spivey, in press).

We find much to agree with in Veissière et al.'s qualitative description of how cognition and culture interact. However, much of this is well-worn territory. The main advance proposed in the target article is that the FEP and TTOM integrate an impressively large number of theories and hypotheses of cognition, social learning and cultural evolution. However, given the authors' extremely underspecified mathematical model, we remain unconvinced by this claim.

The mathematical model presented in the target article is too imprecise to be useful in its current form. The authors do not describe what the terms of the model represent in a cultural or cognitive system or show how the model does any scientific work. Indeed, the FEP is not actually a model of *anything,* but rather a paradigm for describing the behavior of systems that must themselves be modeled. It is fine to start theorizing with a general model (see, for example, Frank (1995) on the Price Equation), but useful models must eventually map onto relevant aspects of the world. In the target article's entire mathematical appendix, no parameter is described as representing any aspects of culture, brains, agents, ideas, means, cognitive processes, or any tangible or intangible object related to the purported subject matter. Without this basic modeler's due diligence, we find the discussion of the potential contributions of FEP and TTOM to contribute little.

Take, for example, the "dark room" problem posed in the target article: "if agents aim to avoid unexpected encounters with their environment, we should expect minimally changing sensory environments like dark rooms and correspondingly monotonous sensations to be the most frequently (re)visited states of an organism." Of course, even a moment's consideration resolves this quandary, as strategic action can often dominate over passive non-action, and natural selection will favor it when it does. What does the FEP add to this non-dilemma? The author's state that:

> "the FEP deals with the issue of novelty seeking behavior by formalizing action as being in the game of maximizing the epistemic value of action (or epistemic affordance) … [F]ree energy minimizing agents seek to sample the world in the most efficient way possible. Since the information gain (i.e., salience) is the amount of uncertainty resolved, it makes good sense for the agent to selectively sample regions of environment with high uncertainty, which will yield the most informative observations… In effect, agents will act to optimize the epistemic value or affordance of an action *before* acting on its pragmatic value, which is essentially its expected utility."

This is qualitatively appealing, but adds little value to the current state of scientific understanding. There is already a long history of modeling the trade-off between exploring an uncertain environment and "acting on its pragmatic value" in the social and biological sciences (e.g., Hills et al. 2015; Rendell et al. 2010; 2011). To demonstrate how a model *can* add value, contrast the musings above with a mathematical model studied by Perreault, Moya and Boyd (2012). In their model, a population of agents use Bayesian learning to integrate environmental

and social cues and eventually make decisions in an uncertain environment. They show that individuals optimally weigh social cues (relative to environmental cues) more heavily when the environment is more stable and when environmental cues are more uninformative. They also show that conformist-biased social learning (weighting common behaviors above chance) readily out performs unbiased social learning across a broad range of conditions, especially when environments are novel or cultural transmission is error-prone. Most importantly, they provide an explicit model where agents make decisions and perform actions with measurable outcomes that potentially provide insight into the world. They have gone from the "first principles" of a Bayesian learning process and evolutionary selection to the consequent changes in individual agents' cognition in response to socio-environmental forces.

What added value does the FEP give above and beyond the type of modeling done by Perreault et al? Would an agent using the FEP or TTOM outperform their Bayesian learning agents? Or is the Bayesian learning agent a special case of an agent using FEP or TTOM? Should the overall model dynamics be analyzed using principles of the FEP, and if so, why?

Veissière et al. assert that agents will maximize the epistemic value of an action before its pragmatic value. However, a long of history of models in many disciplines suggest fundamental trade-offs between these goals. As researchers interested in marrying cognition to cultural transmission, the determination of whether the FEP or TTOM are useful cannot be assessed unless their proponents can show how they do useful work in explaining the world.

References:

Bowles, S., & Gintis, H. (2013). *A cooperative species: Human reciprocity and its evolution*. Princeton University Press.

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

Contreras Kallens PA, Dale R, Smaldino PE (2018) Cultural evolution of categorization. *Cognitive Systems Research*, 52, 765–774.

Frank, S. A. (1995). George Price's contributions to evolutionary genetics. *Journal of theoretical biology*, 175(3), 373-388.

Henrich, J., & McElreath, R. (2003). The evolution of cultural evolution. *Evolutionary Anthropology*, 12(3), 123-135.

Heyes, C. (2018). *Cognitive gadgets: The cultural evolution of thinking*. Harvard University Press.

Hills, T. T., Todd, P. M., Lazer, D., Redish, A. D., Couzin, I. D., & Cognitive Search Research Group. (2015). Exploration versus exploitation in space, mind, and society. *Trends in Cognitive Sciences*, 19(1), 46-54.

McElreath, R., & Henrich, J. (2007). Modeling cultural evolution. In RIM Dunbar & L Barrett (eds), *Oxford Handbook of Evolutionary Psychology*, pp. 571-586.

Perreault, C., Moya, C., & Boyd, R. (2012). A Bayesian approach to the evolution of social learning. *Evolution and Human Behavior*, 33(5), 449-459.

Rendell, L., Boyd, R., Cownden, D., Enquist, M., Eriksson, K., Feldman, M. W., ... & Laland, K. N. (2010). Why copy others? Insights from the social learning strategies tournament. *Science*, 328(5975), 208-213.

Rendell, L., Fogarty, L., Hoppitt, W. J., Morgan, T. J., Webster, M. M., & Laland, K. N. (2011). Cognitive culture: theoretical and empirical insights into social learning strategies. *Trends in Cognitive Sciences*, 15(2), 68-76.

Richerson, P., Baldini, R., Bell, A. V., Demps, K., Frost, K., Hillis, V., et al. (2016). Cultural group selection plays an essential role in explaining human cooperation: A sketch of the evidence. *Behavioral and Brain Sciences*, 39, e30.

Smaldino P. E. (2019) Social identity and cooperation in cultural evolution. *Behavioural Processes*, 161, 108–116.

Smaldino, P. E., & Epstein, J. M. (2015). Social conformity despite individual preferences for distinctiveness. *Royal Society Open Science*, 2(3), 140437.

Smaldino PE, Spivey MJ (in press) Mills made of grist, and other interesting ideas in need of clarification [commentary on C Heyes]. *Behavioral and Brain Sciences*.

Waring TM, Goff SH, Smaldino PE (2017) The coevolution of economic institutions and sustainable consumption via cultural group selection. *Ecological Economics*, 131, 524–532.

Zefferman, M. R. (2016). Mothers teach daughters because daughters teach granddaughters: The evolution of sex-biased transmission. *Behavioral Ecology*, 27(4), 1172-1181.

Zefferman, M. R., & Mathew, S. (2015). An evolutionary theory of large-scale human warfare: Group-structured cultural selection. *Evolutionary Anthropology*, 24(2), 50-61.