A theory limited in scope and evidence

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Abstract

What promised to be a refreshing addition to cumulative cultural evolution, by moving the focus from cultural transmission to technological innovation, falls flat through a lack of thoroughness, explanatory power, and data. A comprehensive theory of cumulative cultural change must carefully integrate all existing evidence in a cohesive multi-level account. We argue that the manuscript fails to do so convincingly.

Osiurak and Reynaud's (O&R's) theory of *technical reasoning* does not advance our understanding of cumulative cultural evolution. There are four important deficiencies. First, it does not make a novel contribution. We agree that the study of cumulative cultural evolution would benefit from a better understanding of technological reasoning. However, this idea is not novel. A number of authors have suggested that theories of cultural evolution need to better integrate reasoning processes (Claidière et al. 2014a; Heyes 2012). It is not enough to present another a verbal argument for the importance of technological reasoning. Real progress requires an account of how such reasoning works. What existing cultural evolutionary work does well is provide a theory that explains how individual-level decisions scale up to population-level dynamics (e.g., Mesoudi 2016; Morgan 2016), including experimental studies that investigate individual cognition, phylogenetic approaches that characterize macro-evolution, and theoretical models that link the two. A theory of technological reasoning should link how individuals reason about a task to the innovations they produce, and finally to cultural dynamics. The manuscript is lacking in this regard.

Second, the authors make numerous empirically testable claims without sufficient evidence to move relevant debates forward. For instance, they criticize the cultural niche theory for downplaying the importance of technological reasoning. However, this is a disagreement that can be solved empirically: to what extent does data suggest that cumulative cultural change is constrained and/or directed by technological reasoning? The authors offer frustratingly little hard data for the relevance of technical reasoning. A compelling theory would go beyond stating that technical reasoning is important and, instead, offer evidence that quantifies this importance, shows how technical reasoning shapes cultural change, and makes clear the limitations of cumulative cultural change in its absence. At present, the authors cite only a single (self-authored) study, which does little to convince the reader of the bold statements made in the manuscript.

Third, we question the assertion that individuals can always produce any single solution produced by cultural evolution. To quote the authors, "all of us are smart enough to acquire each piece of information – as well as to produce any kind of innovation – necessary to survive in any single habitat." This claim is empirically dubious. For example, the Polar Inuit lost a number of important skills during an epidemic in the early nineteenth century, including kayaks, bows, and important aspects of snow house construction. For 40 years or so these people lived without these important tools, and none of the several hundred people in the group were able to reinvent them. When a group of Baffin Island Inuit visited them around 1860, they immediately reincorporated them into their technological repertoire (Boyd et al. 2011). There are many other examples (Earl & McCleary 1994). This claim also neglects the fact that cumulative cultural evolution changes the nature of the problems that must be solved. Cumulative cultural evolution not only involves building upon and improving technology from previous generations, it also opens up new niches with new problems. The invention of the wheel, writing, the internet, all introduce new possibilities and new problems to solve. Perhaps more broadly, life in larger groups generated both a need for norms and institutions that maintain cooperation, as well as more potential for innovation. Would a single human, of infinite lifespan, with infinite time, be able to produce the entirety of the current human repertoire? The authors seem to suggest that this would indeed be the case, but competing accounts suggest that it is not individual cognition, but social complexity and inter-connectedness that are responsible for our technological success (Muthukrishna & Henrich 2016). Whether the authors' claim is true or not remains a question unanswered here.

Fourth, the authors emphasize technological reasoning as key to technological change in cumulative cultural evolution, but cumulative cultural evolution involves a large range of domains other than technology: cooking, language, norms, art, knowledge, abstract or not, all change as a result of cultural transmission and become increasingly complicated. A great deal of knowledge essential for survival, like knowledge about hunting techniques and plant detoxification, does not involve technical reasoning of the kind described by O&R. The domain of language, as well, is very different. Although technological products are shaped by functional pressures (a good bow shoots far and accurately), languages serve communication with symbols defined by convention. The exact form of words is irrelevant, as long as everybody agrees on the same form, and languages are shaped by expressivity and learnability instead (Kirby et al. 2008). Art is, perhaps, at the opposite end of the spectrum from technology. It is free to change according to our esthetic preferences, without any objective benchmark to measure against, and intuitive physics is no help in identifying successful designs. Nonetheless, complexity increases as a result of cultural transmission processes, without any need for technical reasoning abilities. If technological reasoning is the key to human uniqueness, it must explain this plethora of culturally governed processes that fall outside of the technological domain.

Finally, the authors' focus on technological reasoning as "necessary and sufficient" conditions for cumulative cultural change is misguided. Existing theory clearly shows that cumulative cultural change can occur through a number of mechanisms, ranging from a guided-variation/technical-reasoning model to a selective-transmission-ofrandom-variation model (Mesoudi et al. 2016). There is no need for "magic bullet" theories, especially when the current state-of-the-art theories suggest that complex cycles of co-evolution of cognition, life-history, social structure and culture are responsible for our species' success (Boyd 2017; Henrich 2016; Laland 2017a).

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Shared intentionality shapes humans' technical know-how

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Abstract

Osiurak and Reynaud argue that cumulative technological culture is made possible by a "non-social cognitive *structure*" (sect. 1, para. 1) and they offer an account that aims "to escape from the social dimension" (sect. 1, para. 2) of human cognition. We challenge their position by arguing that human technical rationality is unintelligible outside of our species' uniquely social form of life, which is defined by shared intentionality (Kern & Moll 2017, *Philosophical Psychology* **30**(3):319–37; Tomasello 2019a, *Becoming human: A theory of ontogeny*. Cambridge, MA: Belknap Press).

Osiurak and Reynaud (O&R) argue that cumulative technological culture (CTC) is made possible by a "non-social cognitive *structure*" (sect. 1, para. 1) enabling humans to acquire technical knowledge and skills. They maintain that CTC "is necessarily based on our extensive *individual cognitive ability* [our emphasis] to acquire and improve techniques" (sect. 1, para. 3), and they offer an account that aims "to escape from the social dimension" (sect. 1, para. 2) of human cognition. The implication seems to be that social cognition is not necessary for humans to develop fundamental technical skills.

We believe that an escape from human sociality cannot succeed because the social nature of human intelligence permeates all aspects of human cognition and cumulative culture. Human technical and instrumental rationality are unintelligible outside of our species' uniquely social form of life, which is defined by shared intentionality (Kern & Moll 2017; Tomasello 2019a). We will deliver two points to make our argument. The first point casts doubt on O&R's thesis that humans' "technical potential" is fundamentally a feature of individual intentionality and instead suggests that humans' technical know-how is rooted in acts of shared intentionality. The second point is methodological. We will argue that the micro-society experiments O&R cite in support of their position do not constitute compelling evidence in favor of the asocial origins of technical knowledge and understanding.

The first point is informed by cognitive developmental psychology. Studies suggest that children do not develop their technical know-how by trial and error or solipsistic hypothesis testing. Instead, their instrumental rationality is shaped in acts of shared agency with competent adults who show them how to use and craft tools and address instrumental problems (Call & Tomasello 1995; Moll 2018). Let us give two examples. It has been established that young children have difficulties to consider water as a tool. When asked – in the absence of any solid tools but in the presence of water – to extract a small object from the bottom of a narrow and deep tube, preschoolers do not come to think of the possibility of pouring water into the tube to make the object float atop (Hanus et al. 2011; Moll 2018). However, when the instrumental usefulness of water is pedagogically introduced to them, most children spontaneously identify the solution and extract the buoyant object by releasing water into the tube (Moll 2018). Another example is provided by young children's tendency to "over-imitate," even when the mechanical structure of a device is entirely transparent (Lyons et al. 2007; McGuigan et al. 2007). When shown irrelevant in addition to relevant action steps in the course of a transparent apparatus' manipulation, most children faithfully imitate the entire procedure, including the irrelevant steps. If humans' technical abilities can be explained by a "non-social cognitive *structure*," as O&R claim, then it would seem that children should be immune to over-imitation and selectively reproduce only the relevant steps. The fact that most children faithfully stick to the adult's demonstration testifies to the significance of social trust in epistemic and technical matters. This trust is rational because in a social world replete with arbitrary conventions, symbolic communication, rituals, and common occurrences of "causation at a distance," it is often too difficult to determine for individual young learners why, or how, something is causally effective.

The second point concerns O&R's claim that micro-society studies prove that individuals can "reverse-engineer" artifacts without any social assistance. Granted, adult individuals can, under certain conditions, deduce the production process of certain artifacts simply by inspecting the end product. But it is doubtful that these individuals would be able to reverse-engineer anything without an extended social learning history in which they were introduced to the use and manufacturing of various tools and other artifacts. Imagine someone with a history like that ascribed to Kaspar Hauser. It is unlikely that this person could individually make out the function of, say, a can opener. Humans' social learning experiences shape their grip on how artifacts are constructed. Because micro-society experiments cannot control for the participants' social biographies, their validity as measures of what can be attributed to individual versus shared intentionality is dubitable. In fact, it can be difficult even for adults with normal socialization histories to individually discern an unfamiliar tool's purpose. In a small study ($N = 21$) we conducted with adults (eight males) between 20 and 68 years ($M = 30$ years), participants were given a cherry/olive pitter and asked what the device is. A single participant gave the right answer; most answers (incl. the modal response "hot glue gun"), were far off. It thus seems that humans' technical understanding shows clear limits without a meaning-providing cultural context, be it in the form of others' demonstrated use of an object or tool shops with labeled object categories, and so on.

With these points of critique, we hope to have shown that human technological culture and its propagation cannot occur without epistemic and technical transactions involving other agents who master the "technai" that render cultural products