The cognitive reality of causal understanding

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Cultural evolutionists have an ambitious agenda. They seek to explain population-level changes in socially learned characteristics using resources from evolutionary biology. The characteristics range from stone tool-use and marriage customs to fairy stories and social media outrage. The resources include modelling techniques from population genetics and assumptions about the innate structure of minds. Starting in the late 1970s, the dominant school of cultural evolution, known as "dual inheritance theory" and the "California school", has argued that individual humans are not especially smart. Our success as a species is founded on our ability to copy one another, faithfully but without much insight. A thriving alternative, known as "cultural attraction theory" and the "Paris school", sees cultural evolution as a more intellectual business, involving "reconstruction" rather than copying. They argue that any improvement in cultural practices is due, not to Darwinian selection where behavioural copying takes the place of genetic replication, but to powerful, innate cognitive processes that enable social learners to interpret and understand observed behaviour [1, 2]. Representing the Paris school, Osiurak, Claidière and Federico recently made a compelling case that "cumulative technological culture" – improvements in tool-use – depend on "causal understanding" [3]. Their article underlines the need for better integration between cultural evolution and cognitive science to resolve the issues that divide California from Paris [4].

Obviously, to work out whether cumulative technological culture depends on causal understanding we need to know what is meant by causal understanding. Osiurak et al. [2] struggle valiantly with this slippery term. They first equate causal understanding with "causal reasoning" and "technical reasoning", implying the three are synonymous. Later, they cast technical reasoning as one species of causal reasoning, distinct from another species, mentalising, in being "analogical" and involving “nondeclarative knowledge about physical principles that is acquired through experience”. This shift is potentially confusing - it means we are considering whether improvements in tool use depend on technical reasoning, rather than causal understanding more generally - but that is a minor glitch.

The trickier problem is to distinguish technical reasoning from associative learning and from non-technical reasoning. Osiurak et al. rise to part of this challenge by appeal to something like the distinction between model-free and model-based learning. They suggest that “Associative learning involves representations about proximal relations (i.e., observable events)” whereas technical reasoning “involves representations about distal relations (i.e., unobservable entities; e.g., physical forces)”. However, they are less forthcoming about the difference between technical reasoning and other kinds of reasoning. In places it seems that, in their view, technical reasoning is distinctive only by virtue of its content; it is reasoning in a generic way but about “physical principles”. In other places, Osiurak et al. assume that technical reasoning involves distinctive processes; it is reasoning in a special way (analogically, causally, nondeclaratively?) about physical principles.

If technical reasoning is merely content-specific, the research reviewed by Osiurak et al., although intriguing in many ways, tell us little about cumulative technological culture. It shows only that those who participated in the reviewed experiments - people alive today in Western cultures – are apt to engage their generic reasoning abilities when observing tool use or working with tools themselves. In contrast, if technical reasoning is both content- and process-specific the work they review suggests that a special way of thinking co-evolved (genetically or culturally; Box 1) with tools; the existence of tools provided selection pressure for this special kind of reasoning, and the special kind of reasoning enabled the tools to improve over time. Osiurak and colleagues imply but do not demonstrate that technical reasoning is process specific. For example, they show that activity of the “tool-use network” (in left IFG and area PF in the left IPL) is correlated with technical reasoning, but we know from other research in cognitive neuroscience that social learning can depend on domain-specific neurobiological processes and domain-general psychological processes [5].

Osiurak and colleagues skilfully mined research in cognitive science for a definition of technical reasoning and evidence bearing on its role in social learning.

The products of their excavation may not be perfect, but they are still exemplary. They put Paris well ahead of California in using cognitive science to resolve fundamental questions about cultural evolution. The California school takes a behaviourist approach. It defines “copying” (or “imitation”) as a process that takes the behaviour of another agent as input and produces matching behaviour as output. The Californians are deliberately agnostic about the cognitive and neurobiological processes underlying this input-output relationship. This reluctance to “enquire within” [4] has served the California school well as a modelling strategy, but it cannot answer the kind of challenge raised by Osiurak and colleagues. To take up their gauntlet, those who believe that technological improvement can be due to Darwinian selection must give copying a “cognitive reality” comparable to that of technological reasoning.

Box 1

Technical reasoning: instinct or gadget?

Where does technical reasoning come from? It could be a cognitive instinct, designed primarily by genetic evolution, which emerges in the same form and sequence across a wide range of developmental environments. Or it could be more like literacy - a cognitive gadget, designed primarily by cultural evolution, that is installed (if at all) by specific kinds of social interaction during development [6]. (Yes, in a mind-bending way, cultural evolution can shape its own processes of inheritance.)

Across contexts, groups and cultures, people reproduce tool use actions with varying degrees of fidelity [7,8]. For example, children in Vanuatu reproduce the components of a sequence of instrumental actions – including causally-irrelevant components (“overimitation”) – more faithfully than children in the US [9]. One might expect technical reasoning to work against the reproduction of causally irrelevant actions. If so, this variability in overimitation implies that technical reasoning is a cognitive gadget, or, whether instinct or gadget, part of a strategy that is flexibly deployed when observing actions on objects [10]. Either way, we cannot safely assume that the use of technical reasoning by people in contemporary Western cultures is representative of the members of other contemporary societies or of our Stone Age ancestors.

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