Commentary on Heyes C. (2019) Précis of Cognitive Gadgets: The Cultural Evolution of Thinking.
Behavioral and Brain Sciences 42, e169: 1–58. doi:10.1017/S0140525X18002145

adaptive in past environments, have since been lost). Over time, humans constructed environments which promoted the development of new cognitive gadgets, which in turn facilitated the development of new environments, and on and on. Co-evolutionary dynamics like this have, in fact, been increasingly studied under the banner of *cultural niche construction* (Kendal 2011; Laland & O'Brien 2011). This body of work explicitly targets the evolutionary feedback processes by which humans modify their environments (e.g., by producing new social institutions like writing), which in turn creates new selection pressures (e.g., by encouraging literacy), which in turn creates new opportunities for modifying the social environment (e.g., by producing new divisions of labor in which some individuals are express stewards of written knowledge), and so on.

All this creates problems for Heyes' central metaphor of grist and mills. There is a reason that the social skills essential to human cultural learning are reasonably well described as being handled by cognitive "gadgets," in the sense that the word usually refers to cobbled-together thingamajigs. The reason is that the environments that led to the evolution of those skills were socially constructed ones – a set of social niches constructed by the same species that was itself developing those skills. These gadgets were pieced together over time by a nonlinear unguided process, and, therefore, they are not pristine engineered devices. The grist was not already there to cause the formation of the mill, nor was the mill already there to cause the formation of the grist. As Heyes herself notes on p. 203, "the inheritance mechanisms for mills overlap with the inheritance mechanisms for grist." Thus, the social environments influencing development (e.g., the grist) co-evolved with the cognitive gadgets (e.g., the mills), bringing each other into being in a fashion not unlike autocatalysis (where two chemical reagents cause each other to come into prominence). To understand something like autocatalysis, one needs some facility with the dynamics of complex systems. Treating cultural evolution and cognitive development as though they are linear feed-forward processes that straightforwardly turn selection pressures into human traits just will not cut it. For example, the social mechanisms of language use and the neural mechanisms of language processing may not be well treated as "a grist" and "a mill," respectively, precisely because they overlap so much with one another (e.g., Clark 2008; Kirby et al. 2008; Spivey & Richardson 2009).

Real mills are traditionally made of wood and stone, or whatever modern materials are currently in fashion. In our unpacking of Heyes' analogy, the mill is formed by the grist, which it then processes in such a way that changes the construction of subsequent mills. If grist can change the way the mill works, and vice versa, then perhaps grist-and-mill is not the right metaphor for understanding the cultural evolution of thinking (most mills don't reshape themselves as a result of changes in the grist that they are milling). If a metaphor is needed, a more apt one might be rivers and the water that runs through them. A riverbed channels the water that runs through a geographical area, but it can also get reshaped by that water. And the quality and flows of that water can change over time. If one embraces a river metaphor to illuminate this mutual relationship between cultural evolution and cognitive gadgets, it is easier to see how culture and brain can indeed shape one another. It also becomes clearer that culture and brain are not two separate factors that additively combine to generate mind. They are sufficiently interdependent that they might be best treated as one complex system: a distributed cognition composed of information that is transmitted via both neural fibers and social fibers.

Instincts or gadgets? Not the debate we should be having

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doi:10.1017/S0140525X19001122, e183

Abstract

I argue, with examples, that most human cognitive skills are neither instincts nor gadgets but mechanisms shaped both by evolved dispositions and by cultural inputs. This shaping can work either through evolved skills fulfilling their function with the help of cultural skills that they contribute to shape, or through cultural skills recruiting evolved skills and adjusting to them.

Cecilia Heyes sharply contrasts two mutually incompatible accounts of the cognitive skills that make humans so special. According to an account she opposes, these skills are biologically evolved cognitive instincts. According to the account she defends, they are culturally acquired "cognitive gadgets" (Heyes 2018). This way of framing the debate is based on a strong presupposition which she barely discusses, namely that there are just two alternatives worth considering: specialised cognitive skills are either instincts or gadgets. Consistent with this presupposition, she treats any argument to the effect that a skill is culturally acquired as showing that it is not biologically evolved, and conversely. Here I want to challenge this presupposition and hence the pertinence of the debate so conceived.

Heyes assumes that the main mechanism through which all animals including humans acquire knowledge and skills is "associative learning," which she views as intrinsically domain-general. Associative learning is complemented by specialised neurocognitive mechanisms. In animal cognition generally, these are cognitive instincts. In the human case, they can also be cognitive gadgets, which are socially learned and culturally evolved. Whatever cognitive instincts humans have, they share with other primates. It is their cognitive gadgets that make humans special. This might sound like a new defence of the nurture side in the old nature-nurture debate, but Heyes herself rejects such simplistic understanding of the issue. "The rich interactive complexity of developmental processes," she notes, "makes it absolutely clear that, in cognition as in other biological systems, there are no pure cases of nature or of nurture; no biological characteristic is caused only by 'the genes' or only by 'the environment'" (Heyes 2018, p. 24).

Still, Heyes has very little to say about the contribution of the environment to the development of instincts: how, for instance, growing up in a given cultural community may contribute to curbing, enhancing, or otherwise shaping human sexual instincts (which are not purely cognitive but have an essential cognitive dimension). Similarly, she has little to say regarding the contribution of the genes to the development of gadgets, which, she maintains, are acquired through associative learning. She views associative learning as a domain-general evolved learning capacity. Associative learning merely enables the acquisition of gadgets but doesn't contribute to shaping their domain- or task-specific characteristic features. There is no place in her account for "learning instincts" (Marler 1991). Gadgets are developmentally disconnected from instincts. Hence her "evo-devo" approach breaks down into an "evo" account of instincts and a "devo" account of gadgets.

Is the partition of cognitive skills into two nonoverlapping clusters – instincts and gadgets – self-evident or at least particularly plausible? I want to suggest that, in fact, the many and varied cognitive skills that make humans special are on a continuum of cases with, at one end, mechanisms the development of which is strongly canalised by biological factors and not much modifiable by environmental factors and, at the other end, mechanisms that are only weakly canalised by biological factors and are particularly susceptible to environmental factors (on canalisation, see Ariew 1996; Waddington 1942). If there is such a continuum of cases and if human cognitive skills stand at various points along the continuum, then the old term "instinct" and the new clever lexical term "gadget" should not be used to partition the whole range but only (if at all) to highlight its end points.

There is a principled reason why, among all biological traits, neurocognitive mechanisms are particularly likely to be scattered along an "innate-acquired" or "instinct-gadget" continuum rather than clustered at one or at both ends. The general function cognition is to adjust the behaviour of the organism to its environment. Sensitivity to the environment is the sine qua non of cognitive mechanisms. When there is selection for one and the same form of behavioural adjustment to the same recurrent local environmental conditions, then the development of the cognitive mechanism involved can be strongly canalised by biological factors. When, on the other hand, the relevant environmental conditions are more varied and complex and hence call for more flexible responses, there are biological-evolutionary grounds to expect weaker canalisation and a greater role of variable environmental factors. This is obviously a matter of degree.

Heyes, on her part, assumes something like this: When a relatively rigid response to recurrent environmental conditions is adequate, selection favours specialised cognitive instincts. When, on the other hand, greater flexibility would be more adaptive, selection favours a radically different alternative: the development and use of a domain-general learning mechanism (such as associative learning). As she points out, "advocates of deep learning, predictive coding, hierarchical reinforcement learning, causal modelling, and Bayesians of almost every stripe" describe these learning procedures as domain-general capabilities (Precis, sect. 1, para. 5). True, but the fact that the formal properties of a learning procedure are best specified without assigning to it any specific domain or goal does not entail that the use of such a procedure in an organism or a machine cannot be tied and adjusted to specific goals.

In defence of her view, Heyes quotes Lake et al. (2017). They however, observed:

> The claim that a mind is a collection of general-purpose neural networks with few initial constraints is rather extreme in contemporary cognitive science. A different picture has emerged that highlights the importance of early inductive biases, including core concepts such as number, space, agency, and objects, as well as powerful learning algorithms that rely on prior knowledge to extract knowledge from small amounts of training data. This knowledge is often richly organized and theory-like in structure, capable of the graded inferences and productive capacities characteristic of human thought." (Lake et al. 2017, p. 5)

In other terms, a Bayesian learning mechanism used for the acquisition and use of information in a given domain can, to good effect, be endowed with priors appropriate to its domain and task making it a specialised mechanism. From an evolutionary point of view, it is quite conceivable that many if not all cognitive adaptations may be specialised Bayesian mechanisms with, among other evolved features, initial priors ready to be readjusted in the course of cognitive development.

Heyes also appeals to general considerations on the course of human evolution. How likely is it that, in the time constraint of human evolution, many new mechanisms should have evolved not just to make culture possible but to shape distinct cultural cognitive skills? This is a reasonable question to which people working on human evolution give different answers. Some, like Joe Henrich (2015), have assumed that a variety of mechanisms targeting specific aspects of culture may well have evolved; others, like Michael Tomasello (1999) or Heyes herself are more sceptical. A consideration that is generally missing in this debate is the fact that cultural skills can be partly shaped not only by an evolved mechanism, the function of which is at least partly fulfilled through these cultural skills; cultural skills can also be shaped by evolved skills that have not evolved to favour any cultural consequence but that are recruited in the process of cultural evolution to make certain skills more learnable.

There are, indeed, two main ways in which biologically evolved dispositions may contribute to shaping a cultural trait. A biological function may be fulfilled through the cultural evolution of an appropriate trait. For instance, humans are omnivorous animals who are biologically disposed to seek a combination of nutrients meeting their biological needs. Cuisines vary from culture to culture and are shaped by cultural histories, social organisation, and local ecologies. They are also, obviously, shaped by evolved food preferences. Hence, the cognitive and practical skills involved in cooking are not appropriately described either as instincts or as gadgets. To take a less trivial example, the biological benefits of "kin altruism" have caused the biological evolution of various forms of cognitive sensitivity to relatedness. Such sensitivity may, in the human case, favour the cultural evolution of relevant cultural skills and practices (Bloch & Sperber 2002).

A second way in which biologically evolved dispositions may contribute to shaping a cultural trait is through cultural evolution taking advantage of biologically evolved dispositions. Heyes, for instance, evokes the work of Dehaene and Cohen (2011) on reading skills. Given the recent history of writing, nobody would argue that reading is shaped by genes that evolved for reading. What Dehaene and Cohen have argued, however, is not that reading is a cultural gadget acquired through associative learning or some other kind of domain-general procedure. Rather, they showed that reading recruits an evolved cognitive capacity implemented in the left lateral occipitotemporal sulcus and the initial function of which is to identify visual patterns relevant to identifying object contours. The cultural evolution of writing and reading has been made possible and has been shaped by this evolved mechanism, taking advantage of its capabilities to create novel visual stimuli.

Sperber and Hirschfeld (2004) have illustrated another way in which biologically evolved dispositions – the function of which is not, or not initially, related to culture – nevertheless provide opportunities for the cultural evolution of cultural skills or practices and contribute to shaping these skills. Consider, for instance, the evolved mental mechanisms that allow humans to recognize individual faces and to interpret facial expressions. The input conditions that a stimulus must meet to trigger the operation of these mechanisms are fulfilled not only by actual faces, but also by face-like items such as pictures of faces, smileys, masks, and so on. Only actual faces are in the "proper domain" of the mechanisms: that is, in the range of items they evolved to process. All items that meet their input conditions, however, whether they fall in the proper domain of the mechanisms or not, fall in their "actual domain" – that is, in the range of items that trigger the operations of the mechanism. Most of these face-like items belonging to the actual domain of face-processing cognitive mechanisms are culturally produced. The production and appreciation of portraits, for instance, is both common and diversified across cultures. Actual faces themselves can be modified (through make-up or hair styling for instance) so as to bias the perception of the face (of its youth, its mood, and so on). There is, in other terms, a range of cultural skills involved in representing and modifying faces and in interpreting these representations and modifications that exploit and extend the actual domain of face recognition. The face recognition mechanisms did not evolve to produce such cultural effects. What happened, rather, is that cultural skills evolved by taking advantage of the biologically evolved face recognition mechanism and populating its actual domain with cultural artefacts.

More generally, human cognitive skills can be shaped by biological evolution, cultural evolution, or both. Some cultural skills are fine-tunings or elaborations of a biological skill, as in the case of cultural food production and appreciation. Such cultural mechanisms typically fulfil biological and cultural functions. Cultural skills may also be exploitations of biologically evolved cognitive skills without serving the biological function of the mechanisms they exploit. Portrait painting or make-up skills are examples in point. Some cultural skills have a more complex relationship with evolved capacities. Such is the case of reading which not only exploits but which also modifies a perception mechanism the initial function of which is to help identify object contours.

So, we are at a stage in the study of the relationship between cognition and culture where, in Heyes' own words, "it remains coherent and important to ask, for any particular characteristic [here, human cognitive skills involved in culture], to what extent and in what ways nature and nurture contribute to its development" (Heyes 2018, p. 25). This, however, does not amount to, or even resemble the task of sorting these skills into instincts and gadgets or of asking whether most of these skills are instincts or are gadgets. This is not the debate we should be having.

Could nonhuman great apes also have cultural evolutionary psychology?

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doi:10.1017/S0140525X19001055, e184

Abstract

Attempted answers are given to (a) whether nonhuman great apes (apes) also have evolved imitation (answer: no); (b) whether humans can transmit imitation as a gadget to apes (answer: yes, partly); (c) whether human-to-ape transmission can kickstart subsequent and stable ape cultural evolutionary psychology ("CEP"; answer: unlikely); and (d) when CEP evolved in our lineage (answer: relatively late).

Heyes (2018) proposes that cultural evolutionary psychology (henceforth CEP), and with it, *cultural* evolution, underlies many human-specific cognitive mechanisms. To mark their cultural source, Heyes calls these mechanisms "cognitive gadgets." A cultural source is certainly likely for some human phenomena (such as Heyes' example of reading). It may also be correct for other mechanisms traditionally regarded as cognitive instincts. I am not completely convinced of all the aspects of CEP (yet?), but to foster readability, my comment will read as if I were already a full CEP convert.

Heyes discusses four cognitive gadgets that form the "mechanisms of cultural learning": selective social learning, mindreading, language, and imitation. Here, I will focus on imitation (the copying of the form of an action[1]). I fully agree with Heyes that imitation is *logically required* for (large) parts of human culture – specifically for culture *based on actions* (Heyes 2018; Tennie et al. 2012).

Any claim for human-specific cognitive abilities benefits from a "control" comparison with humans' closest living relative – that is, for nonhuman great apes (henceforth apes). Heyes (2018) herself frequently mentions apes, but does not clearly say whether, in her view, apes spontaneously imitate or not[2] and whether ape imitation would (have to) be due to an "imitation gadget."

Finding *spontaneous* ape imitation – that is, without any human interference – would mean one of two things: (a) apes may then have a cognitive *instinct* to imitate[3] or (b) they, too, may have evolved their own variant of CEP – including an imitation gadget. Empirically, *if* apes spontaneously imitate in either of these ways, we should see at least two types of evidence: (1) Wild ape behaviour should show "smoking gun" signs of underlying imitation, and (2) captive apes[4] should not *require* human interference to show imitation. Does the current empirical data demonstrate these two patterns?

Imitation transmits the *form* of actions, automatically creating path-dependent differences over time (e.g., due to unavoidable copying error; Eerkens & Lipo 2005). This allows the detection of "smoking gun" signs of imitation: If wild ape cultures were based on imitation, we should see *action form differences* across time and between populations – for example, as different gesture sets/dialects. However, empirically, we find instead *overwhelming similarity in gestural form* across populations – and this extends even to captive populations (see analysis in Byrne 2016). The picture for ape material culture is more complicated but essentially the same: Although these behaviours are more likely to show *differential frequencies* across populations, the forms of also these behaviours neither require nor indicate imitation (e.g., Tennie et al. 2009; 2017).

What about captive apes? *Unenculturated*, apes consistently *fail* to imitate in controlled settings – where imitation would be the sole key to success (Clay & Tennie 2018; Tennie et al. 2012; Tomasello et al. 1997). *After* human training/enculturation