Commentary on Osiurak & Reynaud

Supporting the weight of the elephant in the room: technical intelligence propped up by social cognition and language

Behavioural and Brain Sciences 43, e156: 43-44

Alex Thornton[1,*] Francesca Happé[2] & Christine A. Caldwell[3]

[1] Centre for Ecology and Conservation, University of Exeter, Penryn Campus, TR10 9FE, UK

[2] Social, Genetic, and Developmental Psychiatry Centre, Institute of Psychiatry, Psychology, and Neuroscience, King's College London, SE5 8AF, UK

[3] Department of Psychology, University of Stirling. FK9 4LA, UK

Email addresses

* *Alex Thornton* (author for correspondence): alex.thornton@exeter.ac.uk;

Tel: +44 (0)1326 255081

Christine Caldwell: c.a.caldwell@stir.ac.uk

Francesca Happé: francesca.happe@kcl.ac.uk

URLs:

Alex Thornton: http://www.wildcognitionresearch.com/

Christine Caldwell: https://sites.google.com/site/christineannacaldwell/

Francesca Happé: https://www.kcl.ac.uk/people/francesca-happe

Abstract

We consider the evolutionary plausibility of Osiurak & Reynaud's arguments. We argue that technical reasoning is not quite the magic bullet that O&R assume, and instead propose a co-evolutionary account of the interplay between technical reasoning and social learning, with language emerging as a vital issue neglected in O&R's account.

Main text

For decades, high-fidelity social learning mechanisms like imitation and teaching have been touted as the fundamental pre-requisites for cumulative culture (Boyd & Richerson, 1996; Tomasello, Kruger, & Ratner, 1993). Osiurak and Reynaud (O&R) provide a useful corrective to this narrative, instead highlighting technical reasoning as the overlooked "elephant in the room". We are largely sympathetic to this argument – indeed our own transmission chain experiments demonstrate that cumulative improvements in tools can occur in the absence of opportunities for teaching and imitation (Caldwell & Millen, 2009; Zwirner & Thornton, 2015). However, we are sceptical that technical reasoning represents a magic bullet for understanding cumulative culture.

First, O&R's account is evolutionarily implausible, as it assumes that ancestral hominins must have made a giant cognitive leap to evolve modern technical reasoning skills before cumulative culture could get off the ground. O&R provide no suggestions as to what selective pressures might drive the evolution of technical reasoning in ancestral populations. If we are to understand the origins of human cumulative culture, a focus on proximate cognitive mechanisms must go hand-in-hand with attempts to understand ultimate, functional drivers.

Second, by definition, culture of any kind (including cumulative culture) requires social learning (Boyd & Richerson 1985; Mesoudi & Thornton 2018). No account of the origins of cumulative culture can therefore be complete without consideration of how learned behaviour can be transmitted between individuals. O&R suggest that technical reasoning skills may themselves provide the cognitive foundations for imitation and teaching, but this again leaves open the question of how and why technical reasoning skills themselves originated. It also downplays the fact that social learning does pose specific cognitive challenges, not least the need for learners to direct their attention towards potentially profitable sources of social information (Kendal et al., 2018). In both humans and many non-human animals, social learning plays a vital role in the development of many fundamental aspects of behaviour, including parental care, foraging, communication and social conventions (Thornton & Clutton-Brock, 2011; Whiten, 2019). Thus, it is likely that social learning mechanisms pre-dated and indeed scaffolded the later (genetic and/or cultural) evolution of human-like technical reasoning skills. Indeed, evidence suggests that the acquisition of technical skills in children is shaped and guided by social learning from experienced adults (Beck, Apperly, Chappell, Guthrie, & Cutting, 2011; Nielsen, 2013).

The core of O&R's argument is that "cumulative technological culture *originates* in non-social cognitive skills" (our emphasis). A more plausible suggestion is that the sensory, motoric and cognitive mechanisms that underpin technical reasoning co-evolved with social learning in a positive feedback loop as human populations became increasingly reliant on tools and technologies to access resources following our ancestors' invasion of the savannas (Caldwell, Renner, & Atkinson, 2018; Morgan et al., 2015; Zwirner & Thornton, 2015). There is compelling evidence that relatively simple learning processes can allow groups of animals to reach optimal solutions to problems that would be difficult for a single individual (Saldana, Fagot, Kirby, Smith, & Claidière, 2019; Sasaki & Biro, 2017). Thus, the core criteria for cumulative cultural evolution – that is sequential improvements in the performance of behaviour over multiple episodes of social transmission (Mesoudi & Thornton, 2018) – are likely to be present in some non-human animals. Processes similar to those found in other species may well have led to modest, cumulative improvements in early hominin tools. As our ancestors' reliance on tools increased, so too would the benefits of mechanisms to understand how tools work and to transmit that information socially, in turn facilitating the production of more complex and effective tools. Consistent with this argument, evidence shows that teaching provides no clear advantage over other means of social learning in tasks involving structurally simple tools, but begins to provide important advantages as tools become more complex (Caldwell et al., 2018; Zwirner & Thornton, 2015). The mutually reinforcing advantages of teaching and technical reasoning could

therefore ratchet up, eventually opening up entirely new design spaces that could never have been reached without prior episodes of innovation and cultural transmission. Thus, while all putative examples of cumulative cultural evolution in other species are restricted to specific contexts where there is a single, fixed optimum behaviour (for instance, finding the most direct route between two points: Sasaki & Biro, 2017), the scope of human culture is open-ended, with cultural traits that can continually change, recombine and diversify.

The idea that teaching may have played an increasingly important role in human cultural transmission brings us to a vital element that is largely overlooked in O&R's account: language. Critically, language allows us to teach in an almost infinite range of contexts, to pass on information about what not to do (which is all but impossible to extract through reverse engineering alone), and to request specific information when needed. This allows the scope of human teaching to surpass anything seen in other species, where teaching is restricted to specific, species-typical adaptive behaviours such as hunting (Thornton & Raihani, 2008). If the origins of language lie in the need to teach hard-to-learn skills to kin, as suggested by Laland (2017), it is also likely that the evolution of linguistic skills would have altered the selective environment for other cognitive traits. Thus, as our ancestors' linguistic skills evolved, so too would the benefits of being able to represent, and convey information about, unobservable mental states and physical properties, eventually enabling targeted social transmission of technical knowledge from knowledgeable to naïve individuals.

The challenge for students of cumulative culture is two-fold: we must both explain the origins of human cultural prowess – how is it that our ancestors began to diverge from other species? – and the later cumulative elaboration of tools, technologies and conventions. We applaud O&R for highlighting technical reasoning as an important piece of the puzzle, particularly with regards to the latter issue. However, their "technical reasoning hypothesis" cannot be seen as a competing theory to the more conventional emphasis on social learning, but rather as pinpointing one element in a feedback loop through which cognition, culture and technology co-evolve.

Conflicts of interest: None

Acknowledgements: This work was supported by an ESRC grant (ES/M006042/1) to AT, CAC and FH. We are grateful to Amanda Lucas for discussion.

References

Beck, S. R., Apperly, I. a, Chappell, J., Guthrie, C., & Cutting, N. (2011). Making tools isn't child's play. *Cognition*, *119*(2), 301–306. https://doi.org/10.1016/j.cognition.2011.01.003

Boyd, R., & Richerson, P. J. (1996). Why Culture is Common, but Cultural Evolution is Rare. In W. G. Runciman, J. Maynard Smith, & R. I. M. Dunbar (Eds.), *Evolution of Social Behaviour Patterns in Primates and Man* (pp. 77–93). Oxford: Oxford University Press.

Caldwell, C. A., & Millen, A. E. (2009). Social learning mechanisms and cumulative cultural evolution: is imitation necessary? *Psychological Science*, *20*(12), 1478–1483.

Caldwell, C. A., Renner, E., & Atkinson, M. (2018). Human teaching and cumulative cultural evolution. *Review of Philosophy and Psychology*, *9*(4), 751–770. https://doi.org/10.1007/s13164-017-0346-3

Kendal, R. L., Boogert, N. J., Rendell, L., Laland, K. N., Webster, M., & Jones, P. L. (2018). Social learning strategies: bridge-building between fields. *Trends in Cognitive Sciences, 22,* 651-665. https://doi.org/10.1016/j.tics.2018.04.003

Laland, K. N. (2017). The origins of language in teaching. *Psychonomic Bulletin and Review*, *24*, 225–231. https://doi.org/10.3758/s13423-016-1077-7

Mesoudi, A., & Thornton, A. (2018). What is cumulative cultural evolution? *Proceedings of the Royal Society B*, *285*, 20180712. https://doi.org/10.1098/rspb.2018.0712

Morgan, T. J. H., Uomini, N. T., Rendell, L. E., Street, S. E., Lewis, H. M., Cross, C. P., … Laland, K. N. (2015). Experimental evidence for the co-evolution of hominin tool-making teaching and language. *Nature Communications*, *6*, 1–8. https://doi.org/10.1038/ncomms7029

Nielsen, M. (2013). Young children's imitative and innovative behaviour on the floating object task. *Infant and Child Development*, *22*(6), 44–52. https://doi.org/10.1002/icd.1765

Saldana, C., Fagot, J., Kirby, S., Smith, K., & Claidière, N. (2019). High-fidelity copying is not necessarily the key to cumulative cultural evolution: A study in monkeys and children. *Proceedings of the Royal Society B: Biological Sciences*, *286*, *20190729*. https://doi.org/10.1098/rspb.2019.0729

Sasaki, T., & Biro, D. (2017). Cumulative culture can emerge from collective intelligence in animal groups. *Nature Communications*, *8*, 15049. https://doi.org/10.1038/ncomms15049

Thornton, A., & Clutton-Brock, T. (2011). Social learning and the development of individual and group behaviour in mammal societies. *Philosophical Transactions of the Royal Society B*, *366*, 978–987. https://doi.org/10.1098/rstb.2010.0312

Thornton, A., & Raihani, N. J. (2008). The evolution of teaching. *Animal Behaviour*, *75*, 1823–1836.

Tomasello, M., Kruger, A. C., & Ratner, H. H. (1993). Cultural learning. *Behavioral and Brain Sciences*, *16*, 495–552.

Whiten, A. (2019). Cultural Evolution in Animals. *Annual Review of Ecology, Evolution, and Systematics*, *50*, 1–22. https://doi.org/10.1146/annurev-ecolsys-110218-025040

Zwirner, E., & Thornton, A. (2015). Cognitive requirements of cumulative culture: teaching is useful but not essential. *Scientific Reports*, *5*, 16781. https://doi.org/10.1038/srep16781