Title: The evolutionary dance between culture, genes, and everything in between

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Target Article: Ryutaro Uchiyama, Rachel Spicer, and Michael Muthukrishna: Cultural Evolution of Genetic Heritability. *Behavioral and Brain Sciences*, 2021.

Abstract

Uchiyama et al (2021) describe how a more complete measurement of the dynamic nature of culture could help us unmask the true richness of genetic effects on behaviour. I underscore this notion here by reflecting on the role that the dynamic relationship between culture and DNA has played in our evolutionary history and will play in our evolutionary future.

Main Text

As with everything else in the universe, the protein building blocks encoded in our DNA are not very meaningful on their own. They gain their meaning as part of the complex and highly interconnected machinery out of which our minds and behaviours emerge. Here, they transcend their being as an individual particle, and become part of elementary processes that are in constant motion and communication with each other and their surroundings. Out of these processes, multiple levels of higher order processes emerge that also find their meaning in their interconnected and dynamic nature. We, human beings, are such a higher order process and work in a similar fashion: we are individually meaningless and function only as interconnected groups out of which culture emerges, the highest order process known to us. Culture is the social environment where the stories of our lives unfold. Like all other underlying processes, culture is in constant development and engages in an ongoing evolutionary dance with all the underlying processes down to DNA itself.

Uchiyama et al (2021) deliver an important message about the necessity for cultural context in interpreting and understanding the relationship between genes and behaviour. The nature and magnitude of genetic effects are always estimated against a cultural background. This cultural background is dynamic as it keeps changing in its content (cultural innovation) and its reach (cultural diffusion) across time and space. This makes any estimation of heritability or genetic effects only a snap shot of the dynamic relationship between DNA and behaviour. These snapshots have the potential to be informative about our biology and environment, but can be misleading if one is not aware of its dynamic nature. Uchiyama et al (2021) emphasize the importance for genetics research to incorporate this dynamic nature, which could indeed impact our interpretations greatly. Cultural change does not only make certain genetic effects more or less visible for researchers, however, it also does so for nature itself, where it can make genetic effects more deleterious or more advantageous in an evolutionary context. This can turn culture into an, at times, potent natural selection pressure.

The close relationship between our cultural and genetic evolution has led to several revolutions in our evolutionary history which helped us take over this planet. One of the earlier major innovations

occurred ~1.9 million years ago when *homo erectus* started cooking its food, allowing the first human ancestor that made the cross to Eurasia to spend much less time chewing and digesting (Wrangham, 2009). This resulted in a major shift in the gene pool, leading to a smaller digestive tract, which may have freed up energy for a larger brain to develop, capable of more sophisticated cultural innovations. Another major innovation related to our food supply was the agricultural revolution ~12,000 years ago, which has left traces that we can detect in our genomic sequence data today, such as the ability to digest lactose into adulthood (Laland, Odling-Smee, & Myles, 2010). By domesticating plants and animals, our basic dietary needs were more easily met, which allowed us to live in much larger groups and freed up more time for cultural innovations. This gave rise to the first civilizations and more advanced modes of communication, such as writing, substantially expanding the reach of cultural diffusion. A more recent major innovation that greatly advanced our abilities for highly advanced innovations is the Scientific Revolution (~500 years ago), out of which several other major innovations were born soon thereafter: the Industrial Revolution (~300 years ago) and the Information Revolution (ongoing).

The evolution of our culture has brought us to extraordinary heights with respect to innovative potential and far reaching cultural diffusion. We are the first life-form on earth able to read out our own DNA sequence and observe the results of our own evolutionary history on a molecular level. We are able to estimate genetic effects on behavioural, mental, and physical health outcomes, but have only done that for very specific cultural circumstances so far (Mills & Rahal, 2019). It is today much easier to reliably measure our DNA sequence than to capture the dynamic nature of culture in a research setting. By incorporating culture across time and space into our genetic association studies, as suggested by Uchiyama et al (2021), we could estimate how different genes have different favourable or unfavourable effects across different cultural contexts, which may also increase our appreciation for the value of genetic variation. Just as you need different types of proteins to make cells, you need different types of humans for well-functioning cultures to arise. On a larger timescale, where culture acts as selection pressures, nature needs variation to pick parts from to build the machinery of the next generations. Possibly, this type of selection focuses largely on existing common variation rather than rare new mutations. Behaviour is influenced by many genetic variants with small effects, many of them common in the population (Abdellaoui & Verweij, 2021), creating a big space of variation for culture to choose from.

Some of our latest cultural innovations allow us to influence genes in our offspring, and thereby our evolution, much more directly. Genetic effect estimates are already being used to select embryos (Turley et al., 2021), and genetic engineering is developing at a rapid pace (Musunuru et al., 2021). Without a full appreciation for the value of genetic variation, these kinds of interventions will likely be used to decrease disease risk, which will reduce genetic variation. By decreasing genetic variation, we risk decreasing room for adaptation and making the evolutionary dance between genes and culture more rigid. A substantial amount of genetic effects associated with disease risk overlaps with dimensions of healthy variation - autism and bipolar disorder, for example, show positive genetic correlations with IQ and higher education, respectively (Abdellaoui & Verweij, 2021). What is considered healthy behaviour depends on social circumstances and norms, which vary greatly across time and space. Geneticists should aim to incorporate culture in all its richness in order to make us all better appreciate genetic variation in all its richness.

Conflict of interest: None.

Funding / Financial Support: Abdel Abdellaoui is supported by the Foundation Volksbond Rotterdam.

References

- Abdellaoui, A., & Verweij, K. J. (2021). Dissecting polygenic signals from genome-wide association studies on human behaviour. *Nature Human Behaviour*, 5(6), 686-694.
- Laland, K. N., Odling-Smee, J., & Myles, S. (2010). How culture shaped the human genome: bringing genetics and the human sciences together. *Nature Reviews Genetics*, 11(2), 137-148.
- Mills, M. C., & Rahal, C. (2019). A scientometric review of genome-wide association studies. *Communications biology*, 2(1), 1-11.
- Musunuru, K., Chadwick, A. C., Mizoguchi, T., Garcia, S. P., DeNizio, J. E., Reiss, C. W., . . . Kathiresan, S. (2021). In vivo CRISPR base editing of PCSK9 durably lowers cholesterol in primates. *Nature*, 593(7859), 429-434.
- Turley, P., Meyer, M. N., Wang, N., Cesarini, D., Hammonds, E., Martin, A. R., . . . Visscher, P. M. (2021). Problems with Using Polygenic Scores to Select Embryos. *New England Journal of Medicine*, 385(1), 78-86.
- Uchiyama, R., Spicer, R., & Muthukrishna, M. (2021). Cultural evolution of genetic heritability. *Behavioral and Brain Sciences*, 1-147.
- Wrangham, R. (2009). *Catching fire: how cooking made us human*: Basic books.