Just How Special Are Humans?

with Eric Priest, Celia Deane-Drummond, Joseph Henrich, and Mary Meyers, "Introduction to Symposium on 'Just How Special Are Humans?'"; Eric Priest, "Human Uniqueness: Debates in Science and Theology"; Joseph Henrich, "How Culture Made Us Uniquely Human"; Agustín Fuentes, "Distinctively Human? Meaning-Making and World Shaping as Core Processes of the Human Niche"; Cristine Legare, "The Cumulative Quality of Culture Explains Human Uniqueness"; David Reich, "Human Uniqueness from a Biological Point of View"; Alan Mittleman, "'The Mystery of Human Uniqueness': Common Sense, Science, and Judaism"; Jan-Olav Henriksen, "Experiencing the World as the Evolved Image of God: Religion in the Context of Science"; Jennifer A. Herdt, "Responsible Agency: A Human Distinctive?"; Celia Deane-Drummond, "Tracing Distinctive Human Moral Emotions? The Contribution of a Theology of Gratitude"; and John Behr, "Nature Makes an Ascent from the Lower to the Higher: Gregory of Nyssa on Human Distinctiveness."

THE CUMULATIVE QUALITY OF CULTURE EXPLAINS HUMAN UNIQUENESS

by Cristine Legare

Abstract. What explains the unique features of human culture? Culture is not uniquely human, but human culture is uniquely cumulative. Cumulative culture is a product of our collective intelligence and is supported by cognitive processes and learning strategies that enable people to acquire, transform, and transmit information and technologies within and across generations. Technological and social innovations are currently driving unprecedented changes in cultural complexity and diversity. Innovation is a cognitively and socially complex, multistep process that typically requires (cumulative) cultural learning to achieve. I argue that the technological solutions that characterize twenty-first-century innovation can only be explained by understanding both the capacity to learn from and build upon the insights of others and the transmission systems that store the knowledge and technologies of previous generations. Human uniqueness is a product of cumulative cultural learning, transmission, and innovation.

Keywords: child development; cognitive evolution; cognitive science; cumulative culture; cultural evolution; innovation

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Cristine Legare is a Professor of Psychology and the Director of the Center for Applied Cognitive Science at The University of Texas at Austin, TX, USA; e-mail: legare@austin.utexas.edu.

 ISSN 0591-2385

Introduction

In 2013, a 7-year-old African-American girl from Philadelphia named Zora Ball became the youngest to create a full version of a mobile game application. While many 7-year-olds have yet to master two-digit addition and subtraction, Zora built a game using a programming language based on complex mathematics. What explains her precocious feat of technological innovation? Zora was a student at Harambee Institute of Science and Technology Charter School. She created her video game during an afterschool program called the STEMnasium Learning Academy, which teaches students to use open-source software based on a programming language called Bootstrap (Nuwer 2013). While Zora's technological achievement is extraordinary, this educational program regularly teaches preadolescents to pilot drones and program robots.

In 1996, a 13-year-old boy from Freetown, Sierra Leone, named Kelvin Doe, built a battery capable of providing power to multiple households. While many 13-year-olds (and 33-year-olds) lack a basic understanding of electronic circuits, Kelvin used electronic scrap materials to make batteries strong enough to provide electricity during intermittent power shortages in his community (Hudson 2012). What explains his precocious feat of technological innovation? A self-taught engineer, Kelvin went on to build a radio transmitter, a sound amplifier, a three-channel mixer, and a microphone receiver to broadcast a radio station. Like Zora, Kelvin's technological accomplishments are extraordinary, particularly in the absence of formal engineering training. However, youth in communities like his are responsible for building inventions ranging from solar lanterns to water-free sanitation products to electricity-producing windmills.

How does a 7-year-old become an App developer? How does a 13-year-old become an engineer? Why are technological achievements of this complexity possible at this point in human history and were not possible 10,000 years ago? The answers to these questions are similar to the answers to human cultural achievements more generally: species-specific technological and social complexity and diversity are the products of cumulative culture (Legare 2017; Legare 2019; Rawlings and Legare 2021).

Cumulative culture is the process by which new insights are incorporated into existing bodies of socially-heritable knowledge to develop new kinds of social and technological innovations (Tennie, Call and Tomasello 2009; Boyd, Richerson and Henrich 2011; Pagel 2012; Pradhan, Tennie and van Schaik 2012; Whiten and Erdal 2012; Henrich 2015). The technological solutions Zora and Kelvin created can only be explained by understanding the cognitive capacity to learn from, and build upon, the innovations of others and the cultural transmission systems that humans have constructed to store, transmit, and build upon the knowledge and toolkits of previous generations (Legare 2017). Despite the foundational role of tool innovation in human history, unlike language and imitation, tool innovation is not an especially early-developing skill (Rawlings and Legare 2021). Young children, in general, are much better imitators than innovators (Legare and Nielsen 2015). Innovation is a cognitively and socially sophisticated multistep process that typically requires substantial cultural learning to achieve (Rawlings and Legare 2021).

Cumulative Culture

Innovation is the aggregate product of individuals building upon, modifying, and improving existing technologies to create novel ones (Rawlings and Legare 2021). From the invention of ancient stone tools to the development of artificial intelligence, humans have a long history of reproducing, accumulating, and transforming innovations within and between generations (Legare and Nielsen 2015; Legare 2017; Legare 2019). Humans socially transmit an exceptional amount of information that ranges from efficient hunting and gathering techniques to code for computer software (Henrich and McElreath 2003; Boyd, Richerson and Henrich 2011; Tomasello 2016; Fong, Erut and Legare in press). Cultural repertoires consist of complex skills, massive cannons of knowledge, and increasingly sophisticated tools and artifacts.

Humans are unique not only because we have brains adapted for acquiring and transmitting cultural information. We are also unique because we have built systems to create and store cultural technologies (Legare 2017, 2019). Consider that the exponential increase in technological and cultural complexity that characterizes much of extant human populations has occurred primarily in the last 10,000 years, and much of it within the past 100 years. Within these time frames, there is no evidence for correspondingly significant changes in neural complexity or brain size (Muthukrishna and Henrich 2016). Changes in population size and density during that period, which provide more numerous potential innovators and more rapid cultural transmission, are better explanations for increases in cultural complexity than neural changes (Powell et al. 2009).

The cultural environments we live and learn in are the product of the cumulative innovations of previous generations (Odling-Smee, Laland and Feldman 2003; White, Hinde, Laland et al. 2011; Scott-Phillips, Laland and Shuker 2014). The speed of technological innovation is now occurring at an incomparably more rapid rate than in previous millennia due to cultural infrastructure designed for storage and transmission. For example, in a few short years, Kelvin Doe took discarded electronic scrap materials built by others and modified, redesigned, and reconfigured them to create new technology. In doing so, he created technology far more complex than the technologies humans have developed over the vast majority of human history. It took a few years for Kelvin and Zora to learn the complex knowledge systems that it took millennia to develop. Human culture now consists of trillions of tools and artifacts modified from previous versions.

Exceptionally rapid and dramatic changes in the complexity of everyday technologies are now so commonplace that they feel routine, even mundane. The cultural evolution of cameras over the past 200 years provides a compelling example of the extraordinary technological changes in complexity that have occurred in a relatively short time. The high-definition photographs captured by inexpensive and widely available cameras today are made possible by technology exponentially more complex than the first cameras invented a mere 200 years ago (Fong, Erut and Legare in press). This example of rapid improvements in innovations in photographic technology illustrates the cumulative nature of cultural evolution. It also illustrates the astonishing complexity of many of the now commonplace tools and technologies with which even young children currently interact.

As another example of exceptional technological complexity of the modern era, consider mobile devices. Despite their increasing global ubiquity, no individual human can independently build a mobile phone from scratch. Much of our technology, from cameras to mobile phones, is too complicated to understand, much less develop from scratch within one lifetime (Christakis 2019). Could a single individual independently discover electromagnetic fields, radio wave transmission, lithium-ion batteries, and high-resolution lenses? Creating complex technology is possible only through cumulative cultural learning, which makes individuals more innovative by allowing for the accrual of inherited insights (Legare 2019; Muthukrishna and Henrich 2019). For example, the programming language Zora used to create a new mobile App is an example of how an individual learner builds upon the cumulative innovations of previous generations. The computer software she used is the product of decades of technological discoveries from hundreds of thousands of computer software engineers from all over the world iterating and selectively retaining the computational innovations of others.

Cumulative culture requires psychological adaptations that ensure the high-fidelity transmission of cultural knowledge (Chudek and Henrich 2011; Legare and Nielsen 2015; Creanza, Kolodny and Feldman 2017). Our species-typical proclivities for teaching, high-fidelity imitation, and language are critical for the horizontal and vertical transmission of group-specific cultural content (Tomasello, Kruger and Ratner 1993; Gergely and Csibra 2006; Pinker 2010; Legare 2017). These cognitive abilities are supported by the human mind that has evolved to understand other human minds and to navigate complex social group behavior (Boyer, 2018; Hrdy 2009; Diesendruck and Markson 2011; Bjorklund and Ellis 2014). Cognitive biases such as preferences for homophily (Haun and Over 2014), conformity (Muthukrishna, Morgan and Henrich 2016), consensus (Claidière and Whiten 2012; Herrmann, Legare and Harris 2013), prestige (Chudek, Heller, Birch et al. 2012), and normativity (Kenward 2012; Rakoczy and Schmidt 2013) reinforce the acquisition and transmission of culture.

The motivation to build upon the insights of others is due to our social learning strategies. For example, imitation allows us to learn from others more efficiently than individual trial and error learning. The ability to build upon the insights of others in creative and novel ways is the product of cognitive capacities such as cognitive flexibility, causal reasoning, and problem-solving (Davis et al., 2022). These abilities have been selected for through a process of cognitive and cultural coevolution in our species (van Schaik and Burkart 2011; Henrich 2015; Legare 2019).

Cumulative cultural learning entails retaining some existing practices and techniques, discarding others, and adding innovation incrementally through a process of refinement and recombination (Legare 2019). Social and technological innovations must be transmitted within a group and maintain stability over time (Claidière and Sperber 2010; Sperber 1985; Sperber 1996). The cultural ratchet effect is the process by which learners accumulate, modify, and improve upon information from others (Tomasello, Kruger and Ratner 1993). Qualitative changes are the product of novel insights being introduced to and incorporated with existing technologies (Kolodny, Creanza and Feldman 2015; Stout and Hecht 2017). Innovation allows us to adapt to novel environments and challenges, at the individual and group level (Henrich 2015; Laland 2017). The battery Kelvin Doe built was made possible through access to the technological artifacts created by others, which he modified and recombined through a process of cumulative cultural learning. The rapid evolution of battery technology in the past 200 years, from voltaic pile to lithium-ion technology, can only be explained by the processes that enable and motivate cumulative culture (Legare and Nielsen 2015).

We live during an unprecedented moment in history, and the complexity and diversity of information we have access to make the complexity and diversity of the inventions currently being produced possible. The creation of complex tools is a long-standing product of human history, but what is considered innovative is relative to what is currently available. For example, creating vessels to carry water, supplies, or children have all been transformative technological inventions at different points in human history. The invention of the iPhone is possible now and not a hundred years ago, not because our brains are appreciably different than a century ago, but because human technological complexity is. Had Zora and Kelvin lived a hundred years ago, the innovations they created would also be anchored to the technologies available at the time.

The Development of Cumulative Cultural Learning

A primary task of human development is to learn the cultural toolkits associated with the community you interact with. Why do children have such precocious and sophisticated cultural learning capacities? Because they have a lot to learn. Children must learn an extraordinary amount of diverse and increasingly complex information, including languages, beliefs, skills, technologies, values, practices, norms, rules, and rituals of the population they live in (Legare 2019). Our altricial species has an unusually long juvenile period, which has been shaped by natural selection to support extensive cognitive and social development. An extended adolescent period is critical for a species that inhabits highly diverse cultural environments and that must acquire complex and specialized systems of knowledge (Bjorklund and Ellis 2014; Bjorklund 2018; Geary and Bjorklund 2000; Konner 2010; Gopnik, O.Grady, Lucas et al. 2017). Acquiring the cultural toolkit of the population you are part of is a long and challenging process; proficiency is time and labor intensive. For example, in communities where hunting is a critical source of sustenance, mastery is typically achieved in middle age (Kaplan, Hill, Lancaster et al. 2000). The long road to acquiring hunting expertise illustrates that knowledge of animal behavior is a better predictor of success than physical strength. As in the case of the cultural evolution of computer technology, hunting prowess is the product of cumulative cultural learning of innovations that were improved and transmitted over many generations (Fong, Erut and Legare in press).

Children acquire and transmit the cultural repertoire of their communities through social learning (Heyes 1994; Whiten and van Schaik 2007; van Schaik and Burkart 2011; Dean, Kendal, Schapiro et al. 2012; Legare and Nielsen 2015; Hewlett and Roulette 2016; Mesoudi, Change, Dall et al. 2016). Learning by observing or interacting with another person or the technologies of another person is a social process.

Children learn individually and socially through five primary learning strategies—exploration, observation, participation, imitation, and instruction (Legare 2019). These learning methods are universal but vary in frequency and kind as a function of educational institutions, skill sets, and knowledge systems of particular populations (Rogoff 2003; Lancy 2008; Legare 2019). Studying the processes by which children acquire and transmit culture provides insight into what the human mind has been shaped by evolution to attend to, learn, and discover.

The cognitive capacities that allow children to acquire and transmit culture are universal but sufficiently flexible to enable them to learn group-specific beliefs and behaviors (Boyd and Richerson 1985; Legare and Harris 2016; Legare 2017). Cumulative culture requires a cognitive system that can innovate by developing new and improved solutions in response to novel challenges and environments (Legare and Nielsen 2015; Rawlings and Legare 2020). For example, Kelvin Doe built upon the affordances of extant materials (electronic scrap material) to construct technology (batteries) that provided a solution to a problem (power outages).

Nearly all human communities living today have cultural transmission systems in the form of educational institutions called schools. They transmit information primarily vertically from adult experts to child novices (Legare 2019; Fong, Erut and Legare in press). Increasingly, children acquire knowledge and skills, including proficiency with technologies like computer software and electronic equipment, in schools. Successfully functioning in technology-rich environments now often requires decades of formal education.

Schools have been developed to teach learners new cultural technologies, such as computer programming languages. For example, children like Zora are educated in schools designed to teach computer programming and increasingly have access to these technologies at home. Education of this kind provides unique opportunities to master complex toolkits and skill sets. In addition to academic content knowledge, children acquire norms, beliefs, values, identities, rituals, and practices in schools (Rogoff, Correa-Chávez and Cotuc 2005; Fong, Erut and Legare in press).

Schooling is an engine for cumulative cultural learning in general and for innovation in particular. The functions of schools include maintaining and transmitting cultural repertoires within and across generations. They exist as *cultural reproduction devices* (Erut and Legare in prep; Fong, Erut and Legare in press) and are critical to understanding the development of cumulative cultural learning (Legare 2017; Legare 2019). For example, without institutions dedicated to storing information and teaching knowledge and skills, the ability to efficiently build upon the insights of previous generations would not be possible.

Schooling has become so widespread globally that it is now viewed as a natural, essential part of child development to such an extent that it is mandatory for children to attend school in much of the world. Schools now play a central role in shaping the information and skills required for cultural "maturity" (Erut and Legare in prep; Fong, Erut and Legare in press). It shapes more than just content knowledge; growing evidence suggests that schooling profoundly impacts children's interests, cognition, and skill sets (Cole 1996; Rogoff, Correa-Chávez and Cotuc 2005; Gurven, Fuerstenberg, Trumble et al. 2017; Heyes 2018; Ritchie and Tucker-Drob 2018). Attending school has costs as well as benefits. For example, costs include reducing children's opportunities to learn through observation and participation in activities outside the classroom. Benefits include supporting the stability and transmission of cultural knowledge, such as literacy and scientific knowledge that serve critical functions for individual learners and the broader population. Communities have schools not simply based on an individual drive for knowledge but because they ensure the transmission of critical cultural content, ranging from numeracy to norms, within and across generations.

There is variation in all aspects of human cognition and behavior, much of which we cannot yet explain. Children live and learn in more diverse and complex cultural ecologies than the juvenile organisms of any other species; thus, it is critical to study diverse populations of children in order to document and explain the flexibility, resiliency, and uniqueness of human learning (Apicella and Barrett 2016; Nielsen, Haun, Kärtner et al. 2017). Research on cumulative cultural learning provides critical insight into how innovation emerges and changes within and between populations.

Summary

The complexity and diversity of culture in human populations is unmatched by other species (Rawlings, Legare, Brosnan et al. 2021). We live in increasingly complex and diverse environments filled with technologies inherited, accumulated, and transformed over generations. The human mind is designed to create culture and the culture we create forms a critical part of the environment for subsequent changes (Tomasello 2019). Human innovation can only be explained by understanding both the capacity to learn from and build upon the insights of others and the cultural transmission systems that store the knowledge and technologies of previous generations (Legare 2019). Human uniqueness is a product of cumulative cultural learning, transmission, and innovation.

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