The Social Glue of Cumulative Culture and Ritual Behavior

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Abstract:

Cumulative culture, where innovations are progressively incorporated into a population's stock of skills and knowledge, generating ever more sophisticated repertoires, is a core aspect of human cognition that underpins the technological advances which characterize our species. Cumulative culture relies on our proclivity for high fidelity imitation, something that emerged phylogenetically early in our evolutionary history and emerges ontogenetically early in our development. Commensurate with this proclivity to copy others comes a tradeoff that functionally irrelevant behaviors will be easily maintained and transmitted. Rituals are an expression of this. In this paper, I set out the argument that the core cognitive architecture responsible for cumulative culture and technological progress has the same origin as that which propagates rituals: That is, our socially-motivated propensity for engaging in high-fidelity imitation.

Over a million years ago our hominin ancestors began constructing the complex handaxes and cleavers that characterize the Acheulean stone tool industry. The spread of this industry relied on something that is yet to be reliably found in any other animal lineage – a focus towards the specific means required to bring about an outcome (e.g., the sequence of steps used to produce a symmetrical bifacial handaxe) and away from the ultimate goal of the process (e.g., to make a functional butchery tool). This approach to social learning signifies the emergence of a fixation on behaviors whose overarching purpose is to satisfy social motivations. The primary aim in this paper is to outline why this process of high-fidelity imitation, compelled by social motivations, is simultaneously responsible for a mind capable of driving remarkable technological progress whilst simultaneously engaging in (seemingly) functionally-meaningless ritual behaviors.

Cumulative Culture, Imitation and Innovation

The kinds of technological advances that impact, enrich and improve our lives rely, to varying degrees, on innovations being progressively incorporated into our stock of skills and knowledge, ratcheting ever more sophisticated repertoires (*1*). This process is known as cumulative culture. Claims may exist for cumulative culture in other animals (e.g., *2*) but in terms of complexity and diversity there are no parallels to its expression in humans (*3*).

For many authors, cumulative culture is built on our capacities for imitation and innovation (see *4*). Imitation is key as it permits a vast array of skills and behaviors to be transmitted from generation to generation while avoiding the risks and potential costs associated with individual learning. From early in life children show a capacity for acquiring the skills to operate objects and artifacts by copying what

adults do with them. By the time they are 2 years of age children so readily imitate that they will reproduce another's causally irrelevant actions in what has come to be known as overimitation (*5, 6*). For example, Nielsen and Tomaselli (*7*) had an experimenter show children aged 2 to 13 years how to retrieve a toy from a closed box (e.g., by pushing open a trap door). Although the box could easily be opened by hand, the adult complicated the demonstration by unnecessarily swiping an ordinary object across the top of the box in a causally irrelevant manner, then using the same object to open the box in an inefficient and difficult way. Children replicated the model's object use and incorporated the causally irrelevant actions into their response, and, suggesting this is not culturally specific, did so regardless of whether they lived in a large, industrialized Western city or in remote Bushman communities of Southern Africa.

Of course, imitation is not enough for cumulative culture to function. There needs to be a mechanism for change. There needs to be innovation. However, in stark contrast to their capacity for and engagement in imitation, young children appear to lack the capacity for independent tool creation and design. Tool innovation, or the construction of a novel tool in the absence of observing another perform that construction, is a comparatively late developing ability (*8*). Recent investigations into children's tool innovation reveal that children younger than 7 years struggle to create simple tools to achieve a goal if they are given no clues about how the tool could be created or what it might look like (*9, 10*). In a landmark study, children aged 3 to 11 years were presented with a task in which they needed to retrieve a small bucket containing a toy from the bottom of a clear plastic tube (*8*). To realize the goal, they were given a straight pipe cleaner and some distractor items. The solution was to bend a hook on one end of the pipe cleaner to fish the bucket out of the tube, something the

majority of those younger than 7 years failed to do. Highlighting the cultural broadness of this behavior, young children responded similarly to this task whether they grew up in a typical, large Western city or in a small, remote Bushman communities (*11*). It thus appears that when we are young, we are driven imitators but restricted innovators.

The Beginnings of Cumulative Culture

Non-human animals that may be expected to overimitate (domesticated dogs and our closest living animal relatives, common chimpanzees and bonobos) do not – instead they will omit actions modelled to them that are demonstrably redundant (*12-14*). Given the limited evidence for cumulative culture in other animals we can ask when, in our evolutionary history, might it have emerged? Answering this question is challenging given that minds don't fossilize. Fortunately, the products of them can – and it is in this context we can appeal to the archaeological record. Over 2 million years ago our *Australopithecine* and early *Homo* ancestors were engaged in the Oldowan stone tool industry. For most scholars, these early stone tools were primarily made through individual trial and error learning, with their shapes largely controlled by the properties of the raw materials used (*15*). That is, the level of engagement in social learning necessary to support cumulative culture appears not to have been present during this period.

Around 1.75 million years ago the Oldowan transitioned into the Acheulean, the most persistent of all archaeological cultures with its characteristic artefacts, handaxes (see Figure 1) and cleavers (*16*). It has been argued that the hominins who produced the Acheulean shared our modern propensity for overimitation (*17-19*). First, many aspects of Acheulean knapping (the deliberate shaping of stone to make

tools) make it unlikely that the propagation of these tools was achieved via processes of independent invention. For example, their manufacture employs a series of hierarchically organized stages arranged in sequences such that the relationship between execution of the earlier stages and the finished product would be imperceptible to a novice (*20*). Another key feature is the unparalleled homogeneity of the Acheulean: the industry persisted for around 1.5 million years (*16, 21*) and spread as far afield as South Africa and North Wales, and from Morocco to Nepal. The Acheulean even transcends species boundaries, being manufactured by various hominins, including *Homo erectus* and *Homo heidelbergensis*. Critically, the symmetry and size of handaxes have been shown to be more homogenous than would be expected under conditions of random variation, indicating cultural constraints on these factors (*22, 23*). Finally, Acheulean bifaces are deliberately shaped to be symmetrical, often in two planes (see Fig 1), yet butchery experiments suggest this symmetry does not greatly improve their utilitarian value (*24*). Manufacture of these objects was thus maintained across multiple generations as an outcome of overimitation of an approximately, but unnecessarily, symmetrical form.

Existing from around 1.75mya to around 800kya, the unparalleled longevity and ubiquity of the Acheulean thus appears dependent on a mind that left much evidence of high fidelity imitation but little of innovation (*21*). Indeed, it is not until we move into the Middle Paleolithic, around 300 kya, that clear signs of functional innovative approaches to stone tool manufacture emerge in what is known as the Mousterian tool kit (commonly associated with *Homo neanderthalensis*, late archaic humans, and anatomically modern humans) featuring tools specially made for skinning and preparing meat, hunting, and woodworking (for speculation over what might have driven the shift from the Acheulean to the Mousterian see *17*).

There is thus a vast evolutionary pressure shaping our cumulative cultural mind: Pressure exerted relatively early in our *Homo* phylogeny that builds imitation and resists innovation. But what do stone tools have to do with ritual? Key here is that in the construction of Acheulean stone tools we see signs of the devotion to high fidelity imitation which emerges early in modern children and is thought to underpin cumulative culture and by extension new technology. Critically, through reliance on this process, Acheulean stone tools also hint at the emergence of ritual behavior.

Overimitation and Ritual

Almost all human societies feature rituals: conventional, causally opaque procedures, that are uninterpretable from the perspective of physical causality because they lack an intuitive or observable causal connection between the specific action performed (e.g., synchronized dancing) and the desired outcome or effect (e.g., making it rain) (*25*). Consider births, deaths, marriages or any other significant cultural milestone experienced through the lifespan and try to imagine how they would appear without ritual of some form at their center.

Rituals tend to feature actions that are both causally opaque, affording no access to a physical causal mechanism, and goal demoted, affording little-to-no insight into the motives of the ritual actor (see *26, 27*). Ritualized actions cannot therefore be interpreted as serving an exclusively instrumental purpose but are instead interpreted as being motivated by social concerns, such as affiliation with group members or group-relevant norms (*28*). There are multiple ways in which children show social and cognitive preparedness to adopt the ritualized behaviors of those around them (*4, 28*). According to a number of authors the most compelling is overimitation (*18, 29, 30*).

A key feature that overimitation shares with rituals is the focus on the actions used over the outcomes achieved. Highlighting this, in a study by Nielsen and colleagues (*30*), preschool children watched an adult experimenter model redundant actions on a box (e.g., tapping the side of it with a tool) *after* the box had been opened. When given the box and tool, children reproduced the redundant action despite there being no causal value in doing so (the box was open at the time the actions were produced and the toy that had been hidden inside was accessible). Extending this design, young children living in remote Bushman communities in South Africa were shown a sequence of causally irrelevant actions on an opaque box (*31*). For some of the children the actions culminated in a clear goal being achieved (i.e., a desirable sticker was retrieved), for others the goal was made unclear (e.g., the sticker was available but not retrieved) or removed entirely (i.e., there was nothing in the box – the actions did not achieve anything). The children consistently replicated the causally irrelevant actions, but when there was no goal at all the irrelevant actions were reproduced at significantly higher rates and featured considerable additional repetition, redundancy, and stereotypy. Thus, when the actions were most ritualistic and least instrumental children reproduced them with the greatest number of repetitions. This highlights the ease with which children overimitate but also how this proclivity can be simply and easily co-opted to support the uptake of ritualistic actions.

Social Motivations

There is ample evidence that overimitation functions to satisfy social motivations, be they affiliative or normative (see *32*). For example, Nielsen and Blank (*33*) had 4 to 5 year old children sit opposite two adult models. Both experimenters

took turns demonstrating a sequence of actions on a puzzle box that led to it being opened, making a novel toy available for retrieval. One of the models included irrelevant actions in her demonstration whereas the other used only causally relevant actions. When the child was given the box to operate on, one of the adults left the test room. The children proceeded to copy the actions of whomever remained – most tellingly reproducing the irrelevant actions when the model who had used them was still sitting opposite, despite the alternate adult having clearly shown these actions were unnecessary. Other studies have shown that children will actively protest a protagonist omitting a causally irrelevant action after having seen it being modeled, and will do so even after stating that they understand the irrelevant action is not necessary to achieving the modeled goal (see *34, 35*). In line with this, contemporary experimental archaeology studies have highlighted the likely role of social motivations in handaxe construction (see *36*).

There is thus evidence for the early emergence, ontogenetically and phylogenetically, of behavior underpinned by social motivations and that these motivations guide (and guided) learning and skill acquisition decisions. Whether to satisfy affiliative or normative concerns, once social reasons are used to drive decisions about what to learn ritual behavior can easily take hold. Notably, this psychological foundation of a simultaneously technological and ritual mind may mean that arguments about science displacing religious belief will ultimately prove false

A Speculative Link Between Science and Religion

Science may be idealized as a process in which theories or paradigms are evaluated according to a set of values, with the strength of the resulting evidence subjected to test and subsequent peer evaluation. No matter how novel, discoveries in

science build off of an ever-increasing corpus of skill and knowledge that no single individual could develop in his or her lifetime (whether ideas themselves or reliance on previously developed apparatus and/or techniques). In this regard, science can be seen as an expression of cumulative culture. Reflecting this, a number of authors draw developmental links between imitation and children's scientific reasoning (e.g., *37, 38*). Critically, attention has also been drawn to links between imitation and children's understanding of rituals (e.g., *39, 40*). While non-religious rituals exist (e.g., singing 'happy birthday') the most diverse and elaborate ones are found among religious groups (*41*). Indeed, our engagement with rituals in terms of our compulsion to enact them is one reason religions are so pervasive and transmissible (*42*).

Multiple reasons have been proposed to explain why religions have such a hold on our psychology. Irrespective of the reasons, for over a century there have been predictions that an increasing reliance on, and understanding of, scientific frameworks will ultimately result in the disappearance of religion (e.g., *43*). However, to the extent that science is an expression of cumulative culture, and religion is grounded in ritual behavior, such views may prove ultimately invalid given both processes rely on the same cognitive architecture: A socially-motivated imitative mind. That is, irrespective of our capacity to explain more and more of our world by relying on some version of a scientific method ideas appealing to supernatural and untestable approaches have not completely disappeared. It may be this way precisely because the mind, driven as it is by social motivations and shaped to copy everything others do, enables science while simultaneously enabling religion. New research endeavors are now needed to explore this possibility.

Summary

Over a million years ago our ancestors began to manufacture artifacts for reasons that transcended pure functionality and likely satisfied social motivations. This characterized the emergence of a devotion to high fidelity imitation and with it the beginnings of cumulative culture. This same mind became fertile ground for planting ritual behaviors. Thus, in both of its primary components (i.e., the technical side whereby skills and behaviors are rapidly learned through a focus on process and the precise actions used, rather than the outcome achieved) and motivations (i.e., the normative/affiliative side whereby actions will be reproduced even when their causal efficacy is suspect) overimitation provides the bedrock on which cumulative culture and ritual are built in a single unifying package. The last decade has seen an ever-growing corpus of research devoted to understanding overimitation (for an exhaustive list see Table S1 in *44*). As is hopefully evident here, such research promises to not only yield novel insights into the mind of the developing child but to also provide greater understanding of what it means to be human.

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Figure 1. Bifacial handaxes made in the Acheulean tradition. LHS images show a tool made by an experienced knapper highlighting how these artifacts are commonly shaped to be symmetrical in two planes. Underscoring the challenging nature of their construction, RHS images show the best of many attempts by the author under direct, guided instruction from the expert. For a detailed analysis of Acheulean construction techniques see Muller, Clarkson and Shipton (25).