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The Neurology of Culture

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Abstract

The lack of anatomical evolution contrasted with an evident behavioral change in humans during their natural history, from about 200,000 to 700,000 years ago, constitutes something of a puzzle. What explains the behavioral change, a change which is commonly understood as *cultural*? Against the surprisingly widespread but tautological response that the change was driven by culture – which amounts to the unsatisfying argument that culture drives culture, all the way down, or back – this paper presents a theory developed by Andrey Vyshedskiy, whose work on autism and language therapies has led him to an account of the neurobiological basis of voluntary imagination, which here I redescribe as an account of the evolution of the neurology of culture.

Keywords

neurology – culture – prefrontal synthesis – imagination – prefrontal cortex – recursion – evolution

1 Introduction

The lack of anatomical evolution contrasted with an evident behavioral change in humans during their natural history, from about 200,000 to 700,000

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years ago, constitutes something of a puzzle. What happened such that about 70,000 years ago, humans began leaving evidence of a material culture that suggests something quite radical had taken place to cause changes in human behavioral patterns? The puzzle consists in the fact that the fossil record leaves no corresponding evidence of anatomical or cranial changes. What, then, could explain it? The most common, but still unsatisfactory, response is that cultural change produced cultural change. In *The Evolved Apprentice* (2012), Kim Sterelny, as John Sarnecki (2014) notes, argues that "the fundamental change that divides the period between early humans and behaviorally modern ones [...] is not biological or anatomical, but social and environmental" (153). Sarnecki's review is sympathetic to Sterelny's argument that the great leap forward in the development of humanity has to do with what the former summarizes as "cultural practices" (154), since "we can identify no specific biological adaptation responsible" (154) for the change. Nevertheless, in closing his review, Sarnecki points out that "the capacity to develop and sustain these [cultural practices] cannot be independent of the specific biological or neurological structures that makes them possible" (153). Since the fossil record leaves no clues as to what might have happened with respect to physiological evolution, Sterelny is left explaining cultural development with ... cultural development. The question as to what biological or neurological structures make cultural development even possible in the first place, is left unformulated and therefore unanswered.

By 2022, Sterelny's book having been published in 2012, Richerson and Boyd still held hope that "[f]uture neuroscience may provide a complete proximate account of the biological foundations of culture" (Richerson & Boyd, 2022, p. 390), but it had not done so yet. On the other hand, Ilkka Pyysiäinen's book, *How Religion Works: Towards a New Cognitive Science of Religion* (2001), published earlier even than Sterelny, actually formulates the issue in such a way the solution to becomes possible to think. "Religion is a phenomenon based on the human ability to form counter-intuitive ideas, metarepresent them, and treat them symbolically" (as quoted in Tremlin, 2003, p. 256). If religion and culture are or were to great degree coextensive; if as King (1999) argues, "religion" is an abstraction wrought by European science and imposed on other peoples in the age of imperialism, then the cultural as such, in the broadest sense, would be based too on counter-intuition, metarepresentation and symbolic manipulation. In other words, religion – and here to say religion is to say culture – is based on the human ability to imagine, on the human faculty of imagination.

The question then, as to the development of material culture in human development, is the question of the development of human imagination,

which would require, evidently, neurological conditions of possibility. In a suggestively titled article, "The neurobiology of imagination", Agnati et al. (2013) shed light on the "potential neurobiological substrate of imagery and imagination" without theorizing about the emergence and significance of the imagination in terms of biological evolution and human development. Asma's book, *The Evolution of the Imagination* (2017) might best be characterized as an ode to and history of human creativity without providing an account of the literal evolution of the imagination as the very capacity for the phenomenon on which he focuses, improvisation. However, in a number of pieces of published research (2019a, 2019b, 2020, 2021), the neuroscientist Andrey Vyshedskiy has theorized the evolution of the neurology required for imagination, or what we can think of as the neurology of culture. In this short essay, drawing on his articles and their extensive lists of references, my pretension is nothing more than to present Vyshedskiy's work to the readers of the *Journal of Cognition & Culture*, due to what I take to be its obvious value for the study of cognition and culture. It also proposes a resolution to the problem as to what happened to cause or subtend the behavioral changes that mark us off from the rest of the animal kingdom (to some degree at least).[1] Additionally, I believe it answers the question not only of how is culture possible, but why it is necessary.

2 Imagination and Prefrontal Synthesis

Amidst a continuing research career focusing on pulmonary function and health, and autism and language therapies, with an extensive list of related

1 The suggestion that humans are in this way quite distinct from non-human animals is not an expression of human supremacy, nor defense of a point of pride. It is simply an observation. Humans are obviously animals (humanimals?) and subject to evolutionary pressures. Those evolutionary pressures coincided in humans with a mutation, which occurred after a series of others, which allowed the human animal to augment or perhaps express their nature in ways that other animals have not yet been able to do. Because other animals do not have what I am calling the neurology of culture, generation resembles generation, generation after generation. Whatever culture we ascribe to animals in recognition of whatever creativity they express and whatever sorts of learning they pass on to their offspring (for example, according to de Waal [2022] female chimps teach their female offspring the basics of infant care) does not change the fact that PFS has allowed humans a protean cultural creativity that is simply absent in non-human animals. The point is not to cut us off from them, but to nonetheless have some sense of just what this gift(?) is, along with the implications for how we conceive of cultural diversity and analysis and also the future of culture. See Vygostksy (1933), Tatersall (1999), Carroll (2011) on this non-evaluative difference. Another way of looking at this is to see that we do not face a planet of the apes scenario in real life because, in short, apes are not endowed with the neurology of culture.

publications, Andrey Vyshedskiy has found time to develop and publish across a series of recent articles an evolutionary theory of imagination which explains both how culture is possible and why it is necessary. In "Language evolution to revolution" (2019b), Vyshedskiy begins by bringing up the vexing problem which consists in our best theories of the most recent anatomical evolution bringing us to about 600,000 years ago, while the archeological record only gives us evidence of complex material culture as recently as 70,000–50,000 years ago. This is the gap with which I began this essay.

Complex material culture is how I categorize the artifacts that, for Vyshedskiy, imply the development of the "modern imagination" or what he also specifies as "voluntary imagination" (2020). Such artifacts include: "(1) composite figurative arts, (2) bone needles with an eye, (3) construction of dwellings, and (4) elaborate burials" (2019b, 1). These artifacts are significant because they exhibit the ability to combine at least two different images into a new, composite image. Among the questions that bother Vyshedskiy with regard to the gap, is one about language. His research, recall, includes autism and language difficulties and therapies, and he reminds us that "full recursive language depends on the lateral prefrontal cortex (LPFC)" (2). In particular, "only the LPFC can combine objects from memory into a novel mental image according to a sentence's description" (2). The frontal cortex, where the LPFC is located, is "the action cortex"; it is "devoted to action of one kind or another [...]; it can even be the kind of internal, mental action that we call reasoning" (2020, 2), or voluntary imagination. It is important to distinguish between automatic involuntary imagination which is LPFC independent and "voluntary imagination [...] controlled by the LPFC" (2020, 3). Involuntary imagination has to do with the stuff of dreams and so forth, and many animals seem to have it. Deliberate, voluntary imagination, dependent on LPFC development, they seem to lack. Readers of Marx might well be reminded of his distinction between the bees that build a hive one assumes unconsciously, as compared to the architect who can work out and envision his complex construction before even lifting a finger towards erecting it (or telling someone else to do so). The architect is engaging in deliberate imagination, what Vyshedskiy describes as the "the conscious purposeful active LPFC-driven synthesis of novel mental images" (2019b, 3) or, in short, *prefrontal synthesis* (PFS).

PFS, it is crucial to note, is "completely dependent on an intact LPFC" (2019b, 3), and people who have suffered damage to their LPFC exhibit an inability to imagine or work with "objects or persons in a *novel* combination" (2019b, 3). Vyshedskiy gives a number of examples of which I shall only relate one here: "Questions, such as 'If a cat ate a dog, who is alive?' and 'Imagine the blue cup inside the yellow cup, which cup is on top?' can be consistently answered by four-year-old children but commonly failed by individuals with PFS disability"

(2019b, 3). What we are seeing here, as Vyshedskiy puts, is a "deficit in imagination" (2019b, 4).

3 Prefrontal Synthesis, Recursive Language and the Critical Period, Part I

Picture the following: a pink Cadillac parked on the biggest of Jupiter's moons. I've tried to pick things to combine with which readers of this article will have some familiarity, while the combination I hope is somewhat novel. That the reader can muster up an image that corresponds to what I've written is because of PFS. That the reader doesn't muster up an image of Jupiter's largest moon parked on a Cadillac is thanks to PFS. PFS disability would impede either image being formed. That the Cadillac is pink and the moon the biggest of Jupiter's indicates, too, that we are dealing with recursion. Recursive language and PFS go together, which means something like recursive thinking – purposeful imagination, the basis of complex culture – go together too. Each depends on the other (2019b, 7).

In light the problem with which we began, the disconnect between the apparent culmination of our physical evolution ≈ 600,000 years ago and the age of complex material cultural artifacts ≈ 50,000–70,000 years ago, Vyshedskiy reflects on a community of individuals with PFS disability. Such a community would not be able use recursive language nor, ipso facto, recursive thinking. They would not be able to imagine voluntarily. They could communicate, but in the way that non-human animals communicate: not with prepositions or recursion. Their "communication system must have been non-recursive", not really a language at all, except metaphorically, as much as a "rich-vocabulary non-recursive communication system" (2019b, 8).

3.1 *Childhood and PFS*

The connection between recursive language and PFS can be seen in people who were not exposed to recursive language in early childhood. Such people, though their LPFC is not, strictly speaking, damaged, exhibit PFS disability, and it is unfortunately almost impossible to mitigate (much of Vyshedskiy's other research focuses on therapies for mitigation). Regarding language skills like pronunciation, grammar use and vocabulary acquisition, improvement is possible at almost any age (2019b, 11). But PFS has what is called a "strong critical period" which spans the first five years of life. As Vyshedskiy puts it, the "neural infrastructure mediating PFS can only be established in early childhood" (2019b, 11).

4 The Evolutionary Question

Here we come to the crux of the problem with which we began. Why did human development seemingly take a turn, so to speak, perhaps 70,000 years ago, having not taken one for possibly hundreds of thousands of years previously, and having not, apparently, experienced any further anatomical or morphological evolution? Or, if the account of Vyshedskiy is plausible regarding the archeological record of types of complex material culture and the need for something like voluntary imagination to explain them, where did PFS come from? We have already indicated the answer, but it does not stop being a most perplexing one for that. PFS is dependent upon "a purely cultural phenomenon: dialogic communication using a recursive language" (2019b, 12). The perplexity results from the contention that *PFS itself is necessary for the development of recursive language*, since without PFS, we are unable to do recursion in the first place. In short, without PFS in the first place, there can be no recursion; while without recursion, there can be no development of PFS.

Vyshedskiy breaks the problem down more precisely. The problem consists of two parts. First, "dialogs with non-recursive homesign systems do not suffice for the acquisition of PFS" (2019b, 11).[2] That is, children will not acquire PFS in the context of mere vocabulary-rich non-recursive communication systems. Acquisition of PFS requires inclusion in recursive dialogic communications. Second, that inclusion has to take place "during the period of highest neural plasticity, which peaks before the age of two, diminishes greatly after the age of five, and expires completely some time before puberty" (2019b, 12) in modern humans. How could adults ever develop recursive language use without themselves being exposed to it? How could they ever pass on it on to their children if they themselves have never developed it? A solution to this problem will likely shed light on the gap between biological evolution, which seems to have culminated circa 600,000 years ago, and the "delayed" emergence of complex material culture between 50,000 and 70,000 years ago, itself owing to what I am calling here the neurology of culture.

5 The Remus and Romulus Hypothesis

Vyshedskiy solves the problem with what he calls his Remus and Romulus hypothesis. First, he sets the context, noting that there is "no evidence of the

2 Homesign is spontaneous sign language which comprises nouns and even verbs but lacks recursion.

PFS ability in hominins before 65,000 years ago and there is an abundance of clear and unambiguous evidence of the PFS ability in hominins after around 62,000 years ago" (2019b, 16). The evidence includes

> [c]omposite objects executed in bone and cave paintings, bone needles with an eye, construction of dwellings, appearance of adorned burials, and steadfast colonization of the planet [which] are all the external manifestations of PFS. The PFS-related artifacts are highly correlated with each other in time and geography and are associated with Homo sapiens diffusion out of Africa around 70,000 years ago. (2019b, 16)

He notes that paleoanthropologists take such evidence to indicate a momentous change in human development, and refer to it with names like the "Upper Paleolithic Revolution" (Bar-Yosef, 2002), the "Cognitive revolution" (Harari, 2014), and the "Great Leap Forward" (Diamond, 2014). PFS ability would have been necessary for such evidence to be produced. So how was it acquired?

Given that "that early childhood use of recursive language is essential for acquisition of PFS" (2019b, 19), the only plausible explanation is that "phylogenetically, PFS must have been acquired at the same time as recursive language" (2019b, 19). Vyshedskiy continues: "since only children can acquire PFS, it follows that around 70,000 years ago young children must have invented the first recursive language" (2019b, 20). Such children, most plausibly as few as two, and to whom Vyshedskiy gives the names Romulus and Remus, if they could have invented "just a few spatial prepositions" they would have been able to "communicate a nearly infinite number of novel images [...] and therefore their dialogs would have provided enough stimulation to acquire PFS" (2019b, 20).

But here we are still in the position of Sterelny, to whose work I referred in my introduction. It would still seem to be a case of cultural development driving cultural development. We are still within a question-begging paradox.

It is here that Vyshedskiy provides a genetic (biological) solution, after first problematizing the cultural explanation. According to the results of computer modelling, if PFS acquisition owed strictly to cultural developments, it should have emerged much earlier as a result of purely cultural processes that would have become manifest within a few generations of the anatomical evolution which culminated ≈ 600,000 years ago, and left evidence of its emergence in material cultural artefacts of more or less equal age. But artifacts evidencing the level of complexity that interest us, and of such an age, have not been found so far, and indeed, no such artefacts older than ≈ 70,000 years have been

found. The conclusion is that PFS was not present more than 70,000 years ago, and that its appearance must owe something to genetic evolution.

6 PFS, Recursive Language and the Critical Period, Part II

The key to understanding the origins of PFS and recursive language is, according to Vyshedskiy, to be found in an understanding of the changing length of their critical acquisition period:

> The one neurological difference that could have a direct effect on PFS acquisition is the duration of critical [acquisition] period. If the duration of critical [acquisition] period in pre-PFS hominins was shorter than in modern children, that would have decreased the probability of invention of recursive elements and at the same time having enough time to train their dialog-dependent neurological networks essential for PFS [...]. For example, if the critical period for acquisition of PFS was over by the age of two, hominin children would have no chances for acquiring PFS at all. Only a critical [acquisition] period ending at the age of three would have provided a minimal opportunity to acquire PFS. (2019b, 21–22)

What is required then, for PFS development, is a genetically produced delay in the maturation of prefrontal cortex. And indeed, in modern humans, the "PFC remains immature with respect to synaptogenesis for a significantly longer period compared to chimpanzees and macaques" (2019b, 22). The latter, though they may have a somewhat rich vocabulary of signs, and including, especially when raised in recursive contexts with humans, vocalization, never develop PFS and recursive language abilities (2019b, 22).

According to Vyshedskiy, "one or several genetic mutations [must] have fixed in the human population causing this remarkable delay of the PFC maturation schedule. [...] By slowing down PFC development this mutation could have prolonged [the]critical [acquisition] period and enabled children's invention of recursive elements, resulting in recursive dialogs and acquisition of PFS" (2019b, 22).

The reader will by now be able to parse the outlines of the solution to the paradox. A genetic mutation slowed down maturation of the prefrontal cortex in modern humans. Such humans could then develop spontaneous recursive language which at the same time led to the development of prefrontal synthesis or the ability to voluntarily combine images in novel ways. It led to the

appearance of purposeful imagination which left traces in the archaeological record beginning ≈ 60,000 years ago. This is the neurology of culture, its conditions of possibility. We have here an explanation of how culture become possible that is not, itself, merely cultural. But we also have an explanation of why culture is necessary.

7 The Survival Problem: Why Culture Is Necessary

To recap, PFS, voluntary imagination, and thus culture, become possible due to a mutation that leads to what is called PFC maturation delay, which in turn allows for the development of recursive language and PFS simultaneously, due to a biologically determined extended critical acquisition period. Those few (one or two) who first developed PFS, in other words, were young children who provided their own recursive environment, with no need that the adults provide one.

The new problem is one of survival. For the PFC delay mutation itself slows down brain maturation in human offspring which, in simple terms, and as any parent knows all too well, leaves them in all kinds of danger. In Vyshedskiy's words:

> A decrease in the PFC development rate results in a prolonged immaturity when the brain is incapable of full risk assessment. For example, three-year-old chimps often venture away from their mother, but rarely come close to water, their decision-making PFC prohibiting them from doing so. On the contrary, in human children under 4 years of age, drowning is the leading cause of mortality, resulting in over 140,000 deaths a year [...]. The PFC of the four-year-old child is unable to fully assess the risk of drowning. Similarly, three-year-old children cannot be left alone near fire, near an open apartment window, near a traffic road, or in a forest. *In terms of risk assessment, three-year-old humans are intellectually disabled compared to any other three-year-old animal.* From the point of view of risk assessment, an individual with slower PFC maturation rate has lower chances to survive childhood, unless risks are mitigated by culture (e.g., we hold small children by hand near roads and cliffs, buckle them in a high chair, and never let them outside alone). Culture, however, could not have immediately caught up to delayed PFC maturation. Thus, at least initially "PFC delay" is expected to increase childhood mortality. (2019b, 22–23)

The question posed by this scenario is this: while PFC delay caused by genetic mutation answers the question of how PFS could have developed alongside recursive language, without a recursive context provided by parents, it would also have led the "beneficiaries" of the mutation to an early demise, thus inhibiting genetic transmission of the mutation. In short, we could have never become what we are, *en masse*.

Vyshedskiy's solution is to posit that the advantages bestowed by PFS development, by the development of voluntary imagination, led to more or less immediate and quite unprecedented advantages in "hunting enabled by [new forms of] animal trapping, stratagem [new ways of thinking], and new weaponry [that] can easily [account for] dramatic increase in adult survival" (2019b, 23) that was otherwise jeopardized by delayed PFC maturation. In short, if at least (but then again, perhaps only) two children – Vyshedskiy's Remus and Romulus – were born with the PFC-delay mutation, they would have been able to develop between them recursive language and PFS without running afoul of their diminished risk-assessment abilities. They would have developed "near modern imagination: a ticket to dramatically improved hunting by trapping animals, proclivity for fast discovery of new tools through mental simulations and the ability to strategize over clever ways to eliminate other hominin competitors. The 'PFC delay' mutation and recursive language could have then spread like a wildfire through other Homo sapiens tribes carried by new weapons and an elaborate stratagem made possible by the new recursive language" (2019b, 23).

In other words, culture – the ability to imagine the inactionable (or example, God and corresponding predicates) as well as the actionable, for example, new ways of trapping mega-fauna such that they are extinguished, as well as tribal and eventually national pasts and futures, as well as new and ever more complex technologies – becomes not only possible due to PFC-delay but also necessary due to the same delay. Indeed, as PFC-delay "spreads like wildfire" through the population, it became no longer possible to live "naturally", in the sense that chimpanzees, our closest genetic cousins live so, with only the most minimal evidence of culture in the form of rudimentary training by older females of younger ones (de Waal, 2022), a "culture" that never seems to go much further than that. Culture, in other words, is not merely the "secret of our success" (Henrich, 2016), it is our very condition of possibility. More than our intelligence, as Henrich's book makes clear, it is our culture – our ability to imagine what could be and what will never be – that defines us. But our culture does not result, in the first place, from the gradual accretion of culture, as many would have it. It depends on a genetic mutation that allowed

our brains to engage in willed, purposeful, voluntary imagination. We're not so much *homo sapiens* as *homo imaginatus*.

8 Conclusion

We might conclude, briefly, by observing that in becoming cultural we were almost wiped out, but for the promethean power of the imagination which an otherwise debilitating, potentially catastrophic, PFC maturation delay allowed us to develop. Thanks to that power we have, some of us at least, enjoyed standards of living that only a hundred years ago were still, despite our imaginations, quite inconceivable. Of course, the corollary is that we have also brought ourselves to the brink of destruction, if not through war, then through environmental collapse closely pegged to our unprecedented standards of living – and why not both? Can our imagination, which once saved us from the evolutionary determined doomsday from which it emerged, save us again, now from what must ultimately be seen as a kind of culturally determined doomsday towards which, otherwise, we seem to be inexorably transporting ourselves?

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