Review of: "Historical evolution of culture, mind, and language. Considerations basing on Everett´s study upon the Pirahã"

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Prof. Oesterdiekhoff reviews the behavioral repertoire of the Pirahãs with a particular focus on speech and language, use of numbers and calculation, categorical color terms, quantifiers, constraint of communication to nonabstract subjects, and the dominance of hic and nunc, and he discusses some aspects of their culture. He provides an extensive critique of the interpretations of Everett, who as I understand it, lived among and studied the Pirahãs for 30 years. He develops his own explanation for the behavioral repertoire observed. He seeks to account for this repertoire on the basis of a frozen state of Piagetian progression, such that the Pirahãs in effect, behave like children in advanced societies less than four years old. He provides a detailed but leaves one crucial question unanswered: why should they be frozen? Do they have some kind of fundamental disorder of the brain that precludes this? He makes a point that Pirahã children are educable so this does not seem like a viable explanation. He relates the development of the Pirahãs to that of other primitive tribes and, I think correctly, draws the inference that the Pirahãs have a prototypical language and share much in common in their behavioral repertoire with other very primitive tribes.

Prof. Oesterdiekhoff has clearly devoted enormous effort to developing his hypothesis, couched in developmental psychology, and is clearly expert in the field. I am a cognitive neuroscientist and neurologist with a pretty deep understanding of how the brain works and of language in particular. I have familiarity with the grammar of a substantial number of languages. I have particularly focused on population encoding approaches to understanding brain function in terms of the activity of large populations of highly interconnected neurons (parallel distributed processing). I am also a student of Darwinian evolution. I am of course familiar with Piagetian concepts but would not remotely qualify as a developmental psychologist. I also have only passing knowledge of the language of primitive tribes. Therefore, I can only offer suggestions on some alternative ways of thinking about the problem the Pirahãs present.

I think the question of why the Pirahãs appear to be frozen at an early Piagetian stage needs to be answered. Prof. Oesterdiekhoff comes very close to providing the explanation in para 2 p24: “…because their culture and language does not demand them to advance beyond. They don’t receive the required cognitive stimuli and language stimuli that could provoke them to use any developmental windows beyond.” I think this explanation needs to be fronted and you might consider some of the material below to somewhat reformulate this.

I think the place to start is with Darwinian evolution, which in my view was interpreted far too narrowly in Prof.

Oesterdiekhoff's paper. I draw primarily on the many books published by Richard Dawkins, but particularly the *Selfish Gene (Oxford, 1976)*. The general theme of the Selfish Gene is that animals are merely phenotypic vessicles for their genome and to the extent that they are successful in surviving the vicissitudes of their particular environments and are able to pass on their genes, either directly or via relatives, they are evolutionarily successful. However, humans bring much more to the plate: a repertoire of complex behaviors (language included) that provide survival advantage and may enable them to be members of communities or civilizations, which can enormously amplify their survival advantage. Thus, whereas it is uncertain whether or not there has been meaningful evolution of the human genome since neolithic times, there has certainly been major evolution in the behavioral repertoire and language— evolution propelled by the survival advantage of superior mental ability.

In the case of the Pirahãs, the question is how sophisticated does their behavior need to be and how complex their language to be successful in a very limited and highly constant environment? More specifically, does predominant focus on hic and nunc suffice to meet the limited demands of their environment? If their current behavior and language suffice and their population is more-or-less stable, then there is no survival advantage to innovations such as learning to count or increasing the sophistication of their language. And finally, the Pirahãs feel that life is perfect and they are remarkably happy so why would they want to change? In this view, they are not frozen in a low Piagetian stage (more about this below). Rather, there is no survival advantage to them in advancing beyond this stage.

In tribes that develop in more challenging environments, there is a greater need to develop more sophistic strategies, and likely language, to even survive. The addition of civilization confers great advantage but also the enormous demands required to survive in a complex society, hence pressures to develop more sophisticated concepts, technical skills, and language. It also requires competition with others. As Diamond so nicely illustrated (*Guns, Germs, and Steel)*, the cradles of civilization, starting with the Sumerians, all developed in a Mediterranean climate. Fortuitous events like the Sumerian discovery of a wheat mutant, the seed pod of which did not explode at maturity, and the discovery most of the few animals susceptible to domestication, were key. However, because there were other regions that shared the climate and there was extensive intercity and interstate commerce, inventions and technologies developed by one civilization could spread to others. In the process, the sophistication of these societies and the skill sets and languages of each, rapidly advanced to meet the demands of the advances and to enable successful competition with other civilized entities in the favorable climactic belt. The Pirahãs are under none of these pressures.

We now have overwhelming evidence that everything humans know is acquired one experience at a time, starting in utero (newborns are able to distinguish between the language of their mothers and some foreign language). Neural networks encode this experience as changes in neural connection strengths (synaptic strengths). By their structure, these networks have an intrinsic capacity to gain knowledge of the statistical regularities of their experience with the language spoken to them and around them. In the domain of language, the involved networks provide only the scaffold (for details, see Nadeau SE. The Neural Architecture of Grammar. Cambridge: MIT Press; 2012). The knowledge is incorporated over the years. This is certainly contrary to the Chomskian position but it has for some time been clear that his position is completely incompatible with neural structure and function. The brain does not incorporate algorithmic processes. Rather, it implicitly encodes rules and symbols based on the statistical regularities of a language. Perhaps the most eloquent

statement of this position is Elman JL, Bates EA, Johnson MH, Karmiloff-Smith A, Parisi D, Plunkett K. Rethinking Innateness. A Connectionist Perspective on Development. Cambridge, MA: MIT Press; 1996.

I know of no evidence that there is some intrinsic dynamic in the brain that provides the basis for the Piagetian stages. Rather, these stages reflect the benefits of accumulated experience wired into neural connectivity. Thus, it is not too much to suggest that Pirahãs do not progress beyond a low-level Piagetian stage simply because their very simple environment and their correspondingly simple way of life does not provide them the necessary experience. See:

Munakata Y, McClelland JL, Johnson MH, Siegler RS. Rethinking infant knowledge: toward an adaptive process account of successes and failures in object permanence tasks. Psychological Review. 1997;104:686-713; Rogers TT, McClelland JL. Précis of semantic cognition: a parallel distributed processing approach. Behavioral and Brain Sciences. 2008;31:689-748; Schapiro AC, McClelland JL. A connectionist model of a continuous developmental transition in the balance scale task. Cognition. 2009;110:395-411.

There is overwhelming evidence that the brain functions as a nonlinear dynamic computational device. The ability of the brain to encode implicit rules and symbols reflects these nonlinear dynamics. There is suggestive, albeit much more limited evidence, that brain ontogenesis is also a nonlinear dynamic process. There has certainly long been evidence that as brain ontogenesis proceeds relentlessly, the process entails periods when the statistical regularities of certain types of experience can be encoded and once the brain is past such a period, it is not possible for it to later “catch up.” Experiments involving suturing one eye shut in kittens demonstrated that it was only during the first three weeks of life that this could induce organization of the cortical visual system so that it responded only to input from the open eye. This was irreversible. Suturing later than three weeks had no effect. In humans, Bruno Bettleheim observed the tragically stunted behavior of children isolated in attics during World War II and inferred, in a horrible mistake, that autism reflected maternal neglect. Relatively recently we learned of the tragedy of Romanian orphans housed for years in social isolation in what amounted to cages. The profound cognitive and social dysfunction they exhibited was not reversable. The inability of the Pirahã adults to learn numbers and arithmetic (even as it is possible for their children to learn these things) similarly suggests that they have long since passed through the period when they were capable of such learning. Many scientists have posited periods of particular susceptibility to the influence of adverse environments. Others (myself included) suspect that what we are seeing here is simply stages in the ontogenesis of the nonlinear dynamic machine.

Particular environments may play a major role. McIver and Finlay have pointed out the dramatic differences in the challenges posed by dense jungle and relatively open country (e.g., savanna) (McIver MA, Finlay BL. The neuroecology of the water-to-land transition and the evolution of the vertebrate brain. Philosophical Transactions of the Royal Society, B. 2021;377:20200523). In dense jungle, vision is limited to the immediate proximity and action is forced to be primarily reactive. In savanna, large vistas present themselves and there are a number of implicit behavioral options, depending on the locations of cover, predators, other conspecifics, etc. In short, devising and remembering strategies become essential — an intrinsically creative endeavor providing some opportunities for trial and error learning (provided a wrong choice does not prove fatal). The environment of dense jungle provides none of this opportunity/challenge and its associated learning opportunities.

The many behavioral features of the Pirahãs detailed by Oesterdiekhoff certainly seem quite primitive. However, the Pirahãs may exhibit great sophistication in other domains, e.g., the detail of their perception of their surroundings, which could conceivably be exquisite. I have previously coined the terms homo sapiens perceptualis and homo sapiens conceptualis (Nadeau SE. Neural population dynamics and cognitive function. Front Hum Neurosci. 2020;14:50). In the brain, knowledge is stored in exactly the same networks that process perceptions. For example, visual association cortex, located preponderantly on the under surface of the temporal lobes, encodes our visual knowledge of the world and the objects within it and it processes incoming visual information. In a brain developing in an advanced society, priority is placed on knowledge underlying concepts, many advanced. However, in a primitive society, many such concepts are irrelevant whereas the ability to perceive tiny visual nuances of the environment may be paramount. Thus, with the development of the human brain associated with advancing civilization, there is a trade-off between perceptual capacity and knowledge underlying concepts. Richard Feynman's famous diagrams are visually very simple but they convey very complex concepts. The brain literally changes in the couse of advancing civilization.

A modest point (p24 last 2 lines): knowledge underlying concept representations is predominantly encoded in parietal and temporal regions. Sequence knowledge underlying phonology and grammatic morphology is encoded in perisylvian regions, left>>right. Semantic and phonologic/morphologic networks are linked by extensive white matter connections — the neural instantiation of the lexicons. Ventral frontal cortex (Broca's region) enables translation of phonemic sequences into motor programs (incorporating phonetics) and it reconciles representations of sequences of concept representations and their ad hoc modifications with the sequence regularities of grammatic morphology. More dorsal regions of frontal cortex support the sequencing and modification of concept representations and also appear to support the component of verb representations representing thematic role (Nadeau SE. The Neural Architecture of Grammar. Cambridge: MIT Press; 2012 and a recent paper by Bohsali et al., Neural connectivity underlying core language functions. A hypothesis-based descriptive study. In review).