The importance of exploring non-linguistic functions of human brain language areas for explaining language evolution

P. Thomas Schoenemann

Department of Anthropology, Indiana University, 701 E. Kirkwood Avenue
Bloomington, Indiana 47405, USA

Abstract

The evolution of language is a special case of the evolution of behavior. Evolutionary biologists have long recognized that behavioral change drives biological change, rather than the other way around (Hofstätter 2017). This has been largely highlighted specifically with respect to language evolution, this means that cultural evolution will, to a large extent, drive biological evolution. The transition from quadrupedalism to bipedalism, for example, was driven by behavioral changes (Hunt 1994). We do not evolve biped anatomy first, then simply copy it into our environment. Instead, we adapt it to be the most suitable for our needs.

Behavior drives biological evolution, not the reverse

The evolutionary process is iterative, with behavioral changes occurring within each generation driving the system. Biological changes between generations are the result, not the cause of evolutionary change. The evolutionary process is as follows:

1. Individuals are not able to change their genes to be more adaptive, but they may be able to change their behavior. Some species (especially primates) are inherently more behaviorally flexible than others (e.g., apes).

Given this, individuals within each generation will always be seeking new adaptive behaviors if there are inadequate mechanisms to fully accommodate the biological changes (point 1) to better accomplish the (by definition) default task (point 1).

The evolutionary process is fundamentally biased towards modifying pre-existing abilities

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Evolutionary biology has long recognized these as central principles of evolutionary change in the context of human behavior.

"There is little doubt that some of the most important events in the life of man, such as the conquest of land and of the air, were initiated by shifts in behavior" (Jacob 1978, p. 55, emphasis added)

"Evolution does not produce novelties from scratch. It works on what already exists, and is transforming a system to produce new functions or combining several systems to produce a more elaborate one" (Jacob 1977, p. 164, emphasis added)

There are many examples of behavioral change causing biological change in human evolution

- Increasing behavioral adoption of bipedalism (which is possible, but not comfortable, in other species) led to selection for a suite of anatomical changes in the knee, lower leg, feet, and associated neural circuits, which allowed the transition from quadruped to bipedal locomotion (Gray, 1999).

- Cultural changes spurred by technology (e.g., tools, fire) led to significant increases in the density of nutrients (through the consumption of meat and plant-based cooking of foods), which in turn led to selection for smaller digestion, reduced jaw size and associated muscular structures, more proportionate brain size, and differential neural wiring of the visual system (which is specialized for high-nutrient density foods) (Chater, 2005).

- The advent of milking agriculture led to selection for milk-producing animals, which in turn led to selection for improved digestive systems (Figure 1), reduced size in regions of the human brain (Figure 1; Varghese 2009).

- The advent of agricultural activity led to selection for milk-producing livestock. This in turn led to selection for improved digestive systems, as well as selection for other traits (Figure 1; Varghese 2009).

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Thus, our starting expectation for language should be:

- Selective changes in brain circuits subserving language and driven by behavioral changes explaining increased communication.

The evolution of completely new language-specific circuits is inherently unlikely

An evolutionary approach requires that we explore possible models that emphasize the modification of existing behavioral pathways, rather than creating novel circuitry. This is because creating novel circuitry devoted only to language (or other domains) would be unlikely to be the most suitable for that purpose.

Note that "arguments from personal incredulity" (e.g., the banal argument from Hume’s “Law of Ideas”) are not compelling (e.g., most people still cannot personally imagine how biological evolution itself could be valid). Actually testing these models is what needs to be done.

There have been a number of discussions of language evolution that are consistent with this view of behavioral change driving biological change; e.g., Sampson (1975), Lehman (1969), Langer-Kurrlecht and Rumbaugh (1988), Christiansen and Wexler (1999), Christiansen and Wexler (2000), and Christiansen and Wexler (2001). The metaphor of language as an organ growing to the human brain rather than the brain adapting to language (e.g., Christiansen and Chater 2001) is inherently more consistent with evolutionary parsimony than theories positing complex new circuits (e.g., Smith 1998; Ochaly 1997; Waever et al. 2002; Fisher 1994; Peter 1998; and Peter 2009).

Non-primate humans have no homologous language areas

If language adapted to the human brain, there should be evidence of pre-existing neural architecture that would have been fertile ground for appropriate and modified for language. In fact, anatomical, functional, and connectivity data show that specific homologous human language areas and circuits (Broca, Wernicke, etc.) have not been explored to identify non-human primates’ homologs. If so, then we would expect homologs of non-human primate language areas in non-human primates. This has not been done, nor has this issue been even addressed (as far as I am aware).

The existence of these areas in non-human primates should concern anyone arguing that language evolved required the evolution of entirely new language-specific, even grammar-specific circuits. One might argue that the brain areas that are specific during human language, but not in other primates do not have homologs. This has not been done, and there is no issue even being addressed (as far as I am aware).

The existence of these areas in non-human primates indicates they must have necessarily evolved for non-literate purposes. Finding out what functions these areas serve in the non-human species is an important step in evaluating models of language evolution.

Why does Broca’s area have non-linguistic functions in humans? It is not for language

A useful approach is to assess any apparently non-linguistic functions that are processed in Broca’s area in humans. If the "language" is shaped by the brain rather than the other way around, then it would be expected to continue to process this non-linguistic information into humans today. We should be able to find residuals of the putative original non-linguistic functions of these language areas.

Broca’s area has in fact been implicated in a number of non-linguistic tasks. These include: processing non-verbal spatial information in relation to spatial structure and understanding of direction (Menon et al. 2000), sequential patterns of hand-facial movement (Iverson et al. 2009), and non-verbal auditory processing (Jackendoff 2001). Each of these residual tasks that are not used specifically for language is not used specifically for language (but I reveal circuits nevertheless useful for language, and likely fundamental for it).

However, how can we exclude the possibility that these basic skills are already rarely exercised manifestations of the evolution of new language areas? Perhaps the “language area” only inherently processes these non-linguistic functions, but not these actual functions in isolation. There are two ways to test this position.

First, why should we believe that any language function could be processed by putative “language area” in modern humans when it is claimed language itself could not possibly have pre-existing circuits? Why would language be different from other cognitive functions in this respect? (An answer to this question — that does not rely on “argument from personal incredulity” — has never been offered.

Directly testing the regional models: What do non-primate primates do with their “language” area homologs?

Since these areas are non-linguistic, it should be possible to assess their functional localization in non-human primates. If this could be done, then these areas are also processed in their homologs, but would completely support the hypothesis that these areas evolved specifically for language. Instead, it would support the view that language adapted to pre-existing cognitive architectures, rather than requiring the creation of completely new, language-specific brain areas.

Conversely, if it turns out that these areas are not present in their homologies in humans, it would support the view that complete new circuity would have been necessarily required.

Conclusion

An evolutionary perspective requires us to take seriously the view that behavioral change within generations drove biological evolution between them. This makes the likelihood of modification of pre-existing circuitry inherently more likely than the evolution of completely new, language-specific (let alone grammar-specific) circuits. These two models, however, can in principle be directly tested.

Given that:

1. Human brains are subserved by non-linguistic functions that necessarily appear to be foundational for language.

2. Being non-linguistic, it should be possible to assess their functional localization in non-human primates (at least in principle).

3. Non-human primates have clear Broca’s area homologs.

If these non-linguistic “language”-functional functions are also processed in non-human primates’ Broca’s area homologs, it would support the view that complete new circuity would not be necessarily required. Conversely, if they are not processed in non-human primates, then the view that these new circuits were required for language evolution would be supported. The same approach can and should be applied to all putative “language” areas in humans (e.g., Wernicke’s, the arcuate fasciculus, etc.).