



Reply to comment

# Primates, computation, and the path to language Reply to comments on “Towards a Computational Comparative Neuroprimatology: Framing the language-ready brain”

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## 1. Datasets and models

The target article [6], henceforth **TA**, had as its main title *Towards a Computational Comparative Neuroprimatology*. This unpacks into three claims:

- *Comparative Primatology*: If one wishes to understand the behavior of any one primate species (whether monkey, ape or human – **TA** did not discuss, e.g., lemurs but that study could well be of interest), one will gain new insight by comparing behaviors across species, sharpening one’s analysis of one class of behaviors by analyzing similarities and differences between two or more species.
- *Comparative Neuroprimatology*: This adds the challenge of comparing brains across primate species and seeking to relate comparisons of brain and of behavior.
- *Computational Comparative Neuroprimatology*: Here the aim is to go beyond informal analysis of brain-behavior relations, using computational modeling to assess the contributions of specific brain regions or neural circuitry to

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a class of behaviors in one species, proceeding thence to offer a more detailed analysis of how neural similarities/differences across species can enrich our understanding of behavioral similarities/differences.

We may see this as an important subclass of *computational neuroethology*, providing a particular perspective on ethology, the study of animal behavior more generally. Much current neuroscience uses genetically modified mice to explore neural mechanisms, so future work may increasingly consider mice as “honorary primates” – but this observation points up a major lacuna in the **TA** and the commentaries, namely the role of genetics. However, we do extend the study “upwards” from studying the brain and body of a single individual to the study of social interactions.

The subtitle *Framing the Language-Ready Brain* offers an interlocking set of case studies to exemplify computational comparative neuroprimatology. It combined

- A summary of prior work on the Mirror System Hypothesis (MSH) for the evolution of the human language-ready brain, based on comparison of monkey, ape and human praxis and communication – spanning from [17] and [89] to [4] (*How the Brain Got Language* – henceforth **HBGL**) via many intermediate studies – with
- An account of a true exercise in computational comparative neuroprimatology, namely using modeling of how the macaque brain subserves visuo-manual coordination to ground a model of how chimpanzee brains could support the acquisition of novel gestures, and
- an attempt to better characterize “what it is that evolved” through (computational) neurolinguistics.

None of the commentaries addresses the *general* program of *computational* comparative neuroprimatology; they are divided between those that assess aspects of (non-computational) comparative neuroprimatology, and those that focus on aspects of the human capacity for language in ways that enrich our understanding of the language-ready brain rather than its evolutionary or primatological setting. And some point to relevant modeling of human processing or related efforts in artificial intelligence. To put this in perspective, consider [Table 1](#) (the datasets related to commentaries) and [Table 2](#) (the computational models related to commentaries).

Much work needs to be done to develop databases and attendant neuroinformatics tools to systematize, search and compare the diverse forms of data exemplified in [Table 1](#). In July of 2011, I hosted a Workshop on “Action, Language and Neuroinformatics” to address this issue. The necessary developments are charted in the papers in a special issue of the journal *Neuroinformatics*, with an integrative summary provided in the final paper [9]. A prior effort developed the Neurohomology Database (NHDB) to link data on brain mechanisms for action (macaque, human) and language (human) with specific concern for data relevant to the evolution of the language-ready brain [10] but, alas, the database is now defunct, and I would like to see the development of NHDB Redux to systematize the relevant data. Subsequent efforts include the Gesture and Behavior Database (GBDB; <http://gbdb.usc.edu/gbdb/>) which awaits the insertion of data on ape gesture and behavior.

None of the commentaries offer us examples of modeling efforts that explicitly compare models of brain mechanisms in different species. The general challenge to be addressed, then, is how such models may be generated and compared, although [Figure 4](#) and the attendant text (Section 1.5) of **TA** do suggest how to use models of monkey brains to ground modeling of ape brains and human brains within an evolutionary perspective. Indeed, more effort is needed on a related problem: Even when working with the same species, how does one compare two or more models of related phenomena – not simply to judge one better than another, but rather to determine how to combine the best features of the models to expand explanatory power while reducing unwarranted assumptions? The Brain Operation Database (BODB; <http://boddb.usc.edu/boddb/>) offers an environment for linking descriptions of brain models to summaries of the empirical data used to design and test them and includes a simple benchmarking tool for model comparison [16], but more research is needed to build on this foundation.

With this, I turn to the commentaries. My aim is to express my appreciation of each one while trying to integrate them into an overarching methodology for approaching the Language-Ready Brain within an expanding framework for Computational Comparative Neuroprimatology.

## 2. Niche construction

**Stout** [97] reminds us of the emergence of an “extended” evolutionary synthesis which sees organisms as active agents in evolution with inheritance involving more than just genes. A key notion here is *niche construction* [70].

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