Available online at www.sciencedirect.com

ScienceDirect

Physics of Life Reviews 11 (2014) 375–376

PHYSICS of LIFE reviews

www.elsevier.com/locate/plrev

Comment

Decomposing dendrophilia
Comment on “Toward a computational framework for cognitive biology: Unifying approaches from cognitive neuroscience and comparative cognition” by W. Tecumseh Fitch

Henkjan Honing *, Willem Zuidema

Amsterdam Brain & Cognition, Institute for Logic, Language and Computation, University of Amsterdam, Amsterdam, The Netherlands

Received 27 May 2014; accepted 2 June 2014

Available online 26 June 2014

Communicated by L. Perlovsky

The future of cognitive science will be about bridging neuroscience and behavioral studies, with essential roles played by comparative biology, formal modeling, and the theory of computation. Nowhere will this integration be more strongly needed than in understanding the biological basis of language and music. We thus strongly sympathize with the general framework that Fitch [1] proposes, and welcome the remarkably broad and readable review he presents to support it.

We do not share, however, Fitch’s faith in trees as all-compassing model of language and music, and in the branch of computing theory that takes trees (and the Chomsky Hierarchy) as central notions. We do not deny, of course, the existence of structure in language and music. This structure is, at an abstract level of description, often well-captured with hierarchical trees (cf. [2]). But as we zoom in on the neural basis of this structure, important questions arise about the cognitive reality of the building blocks of tree-based descriptions: the symbolic nodes, the ordering of the branches, and the implied hierarchical levels.

We first note that it has proven very difficult to demonstrate true hierarchy at work in language and music, and to exclude non-hierarchical explanations for observed long-distance relationships [6] or for the recognition of stimuli defined by a context-free grammar [7,8]. Many purported proofs of tree structure have difficulties avoiding circularity (cf. [3]): the leaves of an analytic tree (e.g., a metrical analysis) are presented as a result of a structural interpretation to which these leaves (letters or notes) are, in fact, the input [4].

We believe that the difficulty of empirically demonstrating the cognitive reality of trees has a deep cause: ultimately, computing in the brain is based on electrical and chemical substrates that vary on continuous scales. How discrete and tree-like structures may emerge from such a continuous basis is an important research question for cognitive science (but see [5] for one proof-of-concept). With exact answers to that question still lacking, however, it is important to realize that a continuous system may approximate the behavior of a discrete idealization to an arbitrary degree and still remains at heart a continuous system. Trees might thus provide a good description for some aspects of the behavior

DOI of original article: http://dx.doi.org/10.1016/j.plrev.2014.04.005.

* Corresponding author.

http://dx.doi.org/10.1016/j.plrev.2014.06.020

of a system, but fail for other aspects, and completely disappear when zooming in, because the primitive operations of the system are very unlike trees.

This undermines both the usefulness of the Chomsky Hierarchy – defined using symbolic rewrite operations as primitives – and the plausibility, and perhaps even the falsifiability, of Fitch's dendrophilia hypothesis, which sees trees as the underlying cognitive representation rather than as an emergent property and useful abstraction of the researcher. Our view, in contrast, stresses the continuous nature of the brain. This makes it easier to understand why some aspects of language and music – for instance, the rhythmic signal – are essentially continuous, while other aspects – rhythmic categories or note durations – are more readily described in a discrete way (cf. [3]).

In conclusion, we strongly believe in the benefits of building computational models of music and language, using notions that find substrates in neuroscience and cognitive biology. That necessitates a view of computation that takes analogue processes, rather than tree operations, as primitive.

References

[1] Fitch WF. Toward a computational framework for cognitive biology: unifying approaches from cognitive neuroscience and comparative cognition. Phys Life Rev 2014;11:329–64 [in this issue].

[2] Honing H. The illiterate listener. On music cognition, musicality and methodology. Amsterdam University Press; 2011.

[3] Honing H. Structure and interpretation of rhythm in music. In: Deutsch D, editor. Psychology of music. 3rd edition. London: Academic Press/Elsevier; 2013. p. 369–404.

[4] Lerdahl F, Jackendoff R. A generative theory of tonal music. Cambridge (MA): MIT Press; 1983.

[5] Rodriguez P. Simple recurrent networks learn context-free and context-sensitive languages by counting. Neural Comput 2001;13:2093–118.

[6] Thompson-Schill S, Hagoort P, Honing H, Koelsch S, Lerdahl F, Steedman M, et al. Multiple levels of structure in language and music. In: Arbib M, editor. Language, music, and the brain: a mysterious relationship. Strüngmann Forum reports, vol. 10. Cambridge (MA): MIT Press; 2013.

[7] van Heijningen CAA, de Visser J, Zuidema W, ten Cate C. Simple rules can explain discrimination of putative recursive syntactic structures by a songbird species. Proc Natl Acad Sci USA 2009;106:20538–43.

[8] Zuidema W. Context-freeness revisited. In: Proceedings of the 35th annual meeting of the Cognitive Science Society. CogSci'13. Lawrence Erlbaum Associates; 2013. p. 1664–9.

Toward a computational framework for cognitive biology: unifying approaches from cognitive neuroscience and comparative cognition. 2014. 14.79Physics of Life Reviews. 1 Author (W. Tecumseh Fitch). 103 Citations. Read Later. The evolution of cognition as the evolution of high order control. 2016.Â Abstract Interest in incorporating life history research from evolutionary biology into the human sciences has grown rapidly in recent years. Two core features of this research have the potential to prove valuable in strengthening theoretical frameworks in the health and social sciences: the idea that there is a fundamental trade-off between reproduction and health; and that environmental influences are important in determining how life histories develop. cognition. W. Tecumseh Fitch. Dept. of Cognitive Biology, University of Vienna, 14 Althanstrasse, Vienna, Austria Received 5 February 2014; accepted 9 March 2014 Available online 13 May 2014 Communicated by L. Perlovsky. Abstract.Â 1.5. Toward a computational framework for comparative cognition. Here I will proceed by identifying some relatively uncontroversial well-formalized principles of neural computa-tion, and then providing suggestions for how these can be linked to classic cognitive metaphors via the higher-level abstractions of the theory of computation. Determining the cognitive differences between human and nonhuman primates is a central goal of cognitive neuroscience. We show that intuitions of geometry are present in humans but absent in baboons. A simple intruder task in which subjects must find which of six geometric shapes is different reveals an effect of geometric regularity in all human groups regardless of age, education, and culture, yet this effect is absent in baboons. Models of the ventral visual pathway for object recognition predict baboonsâ€™ performance, but a symbolic model is needed to account for human performance.Â , Toward a computational framework for cognitive biology: Unifying approaches from cognitive neuroscience and comparative cognition. Phys. Life Rev.