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Comment

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

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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

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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.

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