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Comment

The software/wetware distinction
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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Fitch [5] has not only articulated a growing consensus, after decades of ideological quarreling, about how to put cognitive science together, but in the process has attempted to advance the unification process with some bold strokes of his own. His proposal [4] that we take seriously the perspective which replaces "spherical neurons" (McCulloch Pitts logical neurons and their close kin) with neurons that are micro-agents with agendas and computational talents of their own, has been taken up by a variety of theorists, including myself [2,3]. Now his dendrophilia hypothesis promises to distill the core truths energizing the heated debates about the innate equipment that distinguishes the cognitive competences of our species from all others. Whether this promise can be kept is a wide-open empirical question, but Fitch has given us enough specification to justify a serious investment in answering it.

One particularly useful achievement of the essay is Fitch's banishment of a host of outdated ideologies: the learned *vs.* innate dichotomy, the autonomy thesis, boxology, and other oversimplifications that have largely outlived their usefulness. I applaud all of these exorcisms save one: there is still much value in the software/hardware distinction when it is applied to *human* minds, as I will try to show briefly. Fitch wastes little time dismissing the distinction:

> At the implementational level, any biologically-grounded theory of cognition will need to accept important differences between neural wetware and contemporary computer hardware. Neurons are living cells – complex self-modifying arrangements of living matter – while silicon transistors are etched and fixed. This means that ap-

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> plying the "software/hardware" distinction to the nervous system is misleading. The fact that neurons change their form, and that such change is at the heart of learning and plasticity, makes the term "neural hardware" particularly inappropriate. The mind is not a program running on the hardware of the brain.
>
> [ms,p. 6]

I have already endorsed the importance of recognizing neurons as "complex self-modifying" agents, but the (ultra-)plasticity of such units can and should be seen as the human brain's way of having something like the competence of a silicon computer to take on an unlimited variety of temporary cognitive roles, "implementing" the long-division virtual machine, the French-speaking virtual machine, the flying-a-plane virtual machine, the sightreading-Mozart virtual machine and many more. These talents get "installed" by various learning processes that have to deal with the neurons' semi-autonomous native talents, but once installed, they can structure the dispositions of the whole brain so strongly that they create higher levels of explanation that are both predictive and explanatory. Stumbling on a Stroop test is a simple example (why do "rouge" and "vert" cause difficulties for some normal subjects and not others?). The taste for dirty limericks (in some suitably structured minds) is a more complicated example. Explaining the difference between good and mediocre chess-playing computers by descending to the hardware level is seldom illuminating, and there is every reason to believe that we will need something very much like the software level to account for many competences and attendant disabilities that psychologists have discovered, measured, and begun explaining. Abilities, preferences, phobias, temptations, goals, and many other recognizable regularities spread rather like viruses through human populations. Unifying the bounty of high-level patterns uncovered by cognitive psychology (and, yes, folk psychology) with the insights from neuroscience is a big part of the unfinished task of cognitive science. A close kin of the hardware/software distinction will be invaluable in that endeavor. At least large parts of the human mind *are* (like) programs running on the wetware [1] of teams of neurons.

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