Learning, epigenetics, and computation: an extension on Fitch's proposal. Comment on "Toward a computational framework for cognitive biology: unifying approaches from cognitive neuroscience and comparative cognition" by W. Tecumseh Fitch

Key Words: Bengalese finches; posterior cingulate cortex; Development; Epigenetics; Tinbergen

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The comparative computational approach of Fitch[1] attempts to renew the classical David Marr paradigm of computation, algorithm, and implementation, by introducing evolutionary view of the relationship between neural architecture and cognition. This comparative evolutionary view provides constraints useful in narrowing down the problem space for both cognition and neural mechanisms. I will provide two examples from our own studies that reinforce and extend Fitch's proposal.

The posterior cingulate cortex has recently been proposed a site of integration necessary for feel of the self [2]. The posterior cingulate in rodents contains unique "late-spiking" neurons, which are activated with a delay of a few seconds after stimulation [3]. We suggested that a cascade of such late-spiking neurons could encode arbitrary delay length, enabling time buffering between sensory and reinforcement stimuli [4]. Consistent with this, ablating this area blocks trace fear conditioning. Now that we provided a neural architecture for a cognitive process, comparative studies using rat and human posterior cingulate may produce, with a proper computational schema like the Bayesian framework, a unique proposal of consciousness and self.

Fitch proposes a Bayesian framework may resolve the nature-nurture controversy. We have been studying the degree of song learnability among species. We found that wild and domesticated Bengalese finches have different degree of learnability given con-specific or hetero-specific songs [5]. When these birds were reared without song tutoring, songs of these two strains already show differences in acoustic morphology [6]. We used the term "learnability" in these papers, but the same concept may be quantitatively treated by a Bayesian prior.

Nico Tinbergen suggested that behavioral studies should include developmental view point [7]. Accordingly, this Bayesian idea could be extended not only for the nature-nurture controversy, but also for epigenetic control, which is the cellular inheritance of gene expression patterns. We found that the same two strains of birds showed different degrees of de-methylation according to song complexity [8]. Epigenetic

control must be involved in the learnability, and the early environmental effect could be expressed as a Bayesian prior.

Taken together, unifying genetic, epigenetic, and learning processes may be accomplished by the Bayesian framework. Furthermore, by introducing developmental and epigenetic views, we can extend Fitch's idea in the framework where the David Marr paradigm and the Nico Tinbergen paradigm are integrated. I thank Fitch for his important proposal.

Acknowledgements

Work supported by the Okanoya Emotional Information Project, JST, Japan, and Grant-in-aids #26240019 and #23118003 from MEXT, Japan.

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