

Krakauer et al.: Neuroscience Needs Behavior: Correcting a Reductionist Bias

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Arne

Gatsby Unit, UCL

Tea talk
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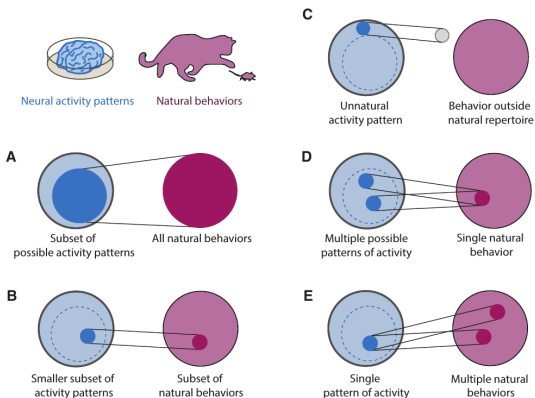
- No prior knowledge of what the *relevant level* of brain organization is for any given behavior
- Same behavior may result from alternative circuit configurations, different circuits, or the same circuit may generate different behaviors
- Example: roundworm – we know genome, cell types, connectome but mapping of this onto behavior is still incomplete

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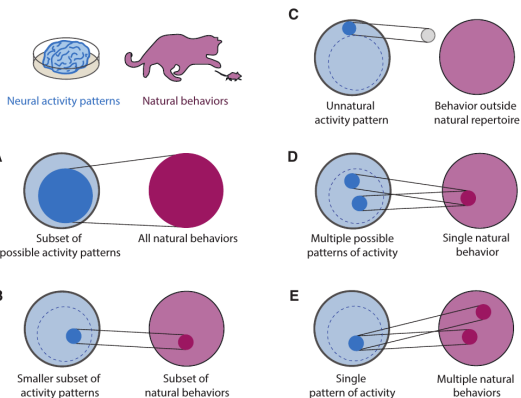


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This concern has been described before by PW Anderson (1972), D Marr (1982) and others

Why are they revisiting this issue?

“It is disturbingly common for studies to include behavior as simply a hasty add-on in papers that are otherwise crammed full of multiple techniques, types of results, and even species. It is as if every paper needs to be a methodological decathlon in order to be considered important. Behavior must be seen as something that can stand alone as a foundational phenomenon in its own right.”

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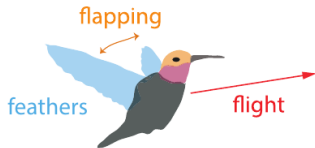
Example (Kuchibhotla et al. Nat Neurosci 2016)

*“Here we take an integrative approach to **measure, manipulate, and model** the impact of **behavioral engagement** on a cortical circuit in behaving mice. We combine*

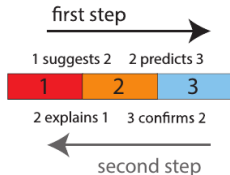
- (i) cell-type-specific **two-photon calcium imaging** to measure network output,*
- (ii) **whole-cell voltage-clamp recordings** of excitatory and inhibitory inputs,*
- (iii) **calcium imaging** of cholinergic axons to monitor neuromodulatory inputs,*
- (iv) **optogenetics** to manipulate all core components of the circuit, and*
- (v) a **theoretical model** to integrate and test the robustness of our findings.”*

Marr's Three Levels of Analysis (again ...)

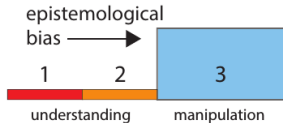
A



B

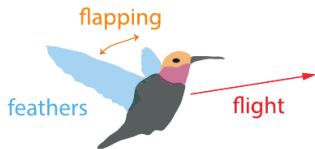


C

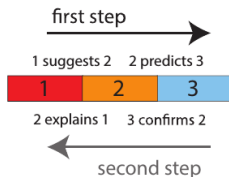


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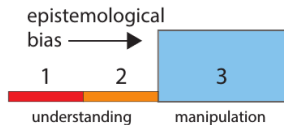
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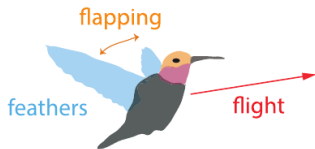


How did we get here?

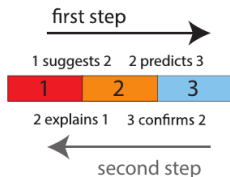
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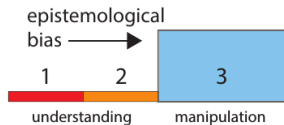
A



B



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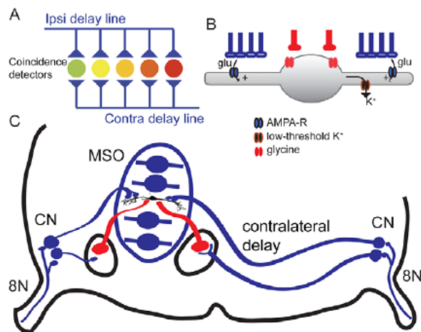


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Publication bias?

Example of interplay between computational theories and algorithmic formulations of behaviors



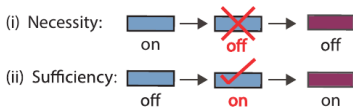
Jeffress (1948)

The Interventionist Type of Understanding Is Not Sufficient

A

What is done



Manipulating a **circuit**
as a way of intervening in **behavior**



B

What is claimed

 is the cause of 

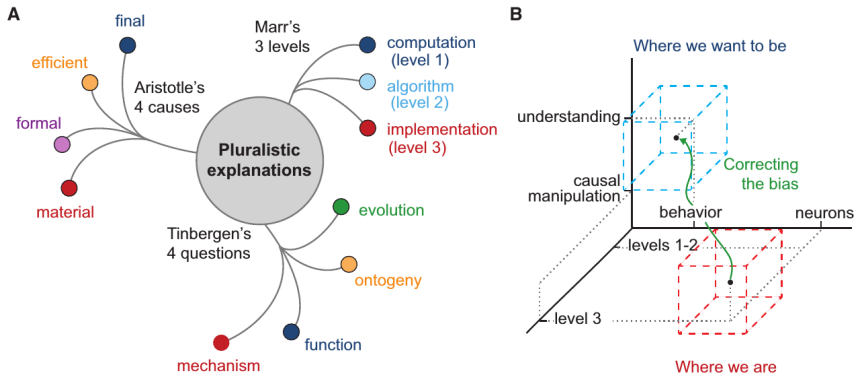
 + "filler" verb = explanation of 

C

Most used "filler" verbs

reflects	encodes
reveals	induces
involves	enables
regulates	ensures
mediates	supports
generates	promotes
modulates	determines
shapes	plays a role in
underlies	contributes to
produces	is associated with

The Future History of Pluralistic Explanation



- *“Here we have argued that when scientists ask “how does the brain generate behavior,” they are in fact asking a question best approached through behavioral work, specifically task analysis, aided by theory, that allows behavior to be decomposed into separable modules and processing operations.”*
- (i) behavior → (ii) neural activity → (iii) manipulate activity/behavior
- Theory that bridges neural (ensemble) activity and behavior is still missing