Are We Ready for a Natural History of Motor Learning?

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General Discussion Questions

• **Role of comparative studies across species** in motor control, perception, decision-making:
  • More explicitly accounting for homology or divergence in species comparisons

• “The observation that all of life shares an evolutionary history imposes enormous regularity on biology in the form of conserved traits amenable to general description and explanation” (Krakauer, 2002).
Comparative Example:
Saccade & Pursuit Interactions in humans vs cats
Comparative Example: Basal Ganglia functional organization in mammals vs insects

Strausfeld and Hirth, 2013
• Role of decomposition and localization approach?

• “We argue that there is continuing usefulness for decomposition and localization as heuristic strategies in mechanism-based neuroscience research (Betchtel and Richardson, 2010)

• “Decomposition is just a starting point or null hypothesis, which in our view is more useful than vague statements about the “loop” or the “whole circuit” doing the work with no suggestion as to how this would be proven experimentally or modeled computationally.”
Krakauer et al., 2017

Neural activity patterns  Natural behaviors

A
Subset of possible activity patterns  All natural behaviors

B
Smaller subset of activity patterns  Subset of natural behaviors

C
Unnatural activity pattern  Behavior outside natural repertoire

D
Multiple possible patterns of activity  Single natural behavior

E
Single pattern of activity  Multiple natural behaviors
Reductionism Example: Cerebellum as locus for motor adaptation?

CRISCIMAGNA-HEMMINGER, BASTIAN, AND SHADMEHR

A

Abrupt

Severe

Mild

Control

Endpoint error (deg)

Null  Field

B

Gradual

Endpoint error (deg)

Null  Field

Trial 1  170  1  70  150  230

Trial 1  170  1  70  150  230
General Discussion Questions

• **Specificity of vocabulary in Motor Control literature**
  • What is really meant by “motor learning”?  
  • Learning to select correct action?  
  • Learning to select correct sequence of actions?  
  • “Motor skill learning”: improving quality of movement (ie: speed and accuracy)

• **Role of motor variability?**
  • Noise? → nuisance variability?  
  • Exploration? → useful variability?
Simultaneity of different learning mechanisms

Mazzoni and Krakauer, 2006
Basal Ganglia

• Evolved from principally targeting tectum in amphibians (control of stereotyped, stim-locked movements) to also targeting cortical regions in reptiles → vertebrates

• Critical for early learning of sequential actions

• Quality of movement rarely assessed in sequential tasks
Basal Ganglia

- Example of distinction between action sequence and kinematic parameterization of action: expert vs. untrained musicians
  - Untrained
  - Learn sequence of notes, over practice refine motor subtleties to mimic the sound they are trying to recreate (tone, accents, timbre, etc)
  - Expert
  - Years of practice solidifies into characteristic motor patterns, song learning more guided by sequence of notes, chords
  - Quality of sound becomes stereotyped, but flexible (individual, transferrable across different sequences/song structures...but flexible (individual & genre-specific styles)

The Basal Ganglia Do Not Select Reach Targets but Control the Urgency of Commitment

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- What model system and paradigm would be best suited to test if there is a transition from control of action selection to vigor/urgency in sequential learning in BG