Does the cortex make a decision?

Readings for today

- Churchland, A. K., Kiani, R., & Shadlen, M. N. (2008). Decision-making with multiple alternatives. Nature neuroscience, 11(6), 693-702.

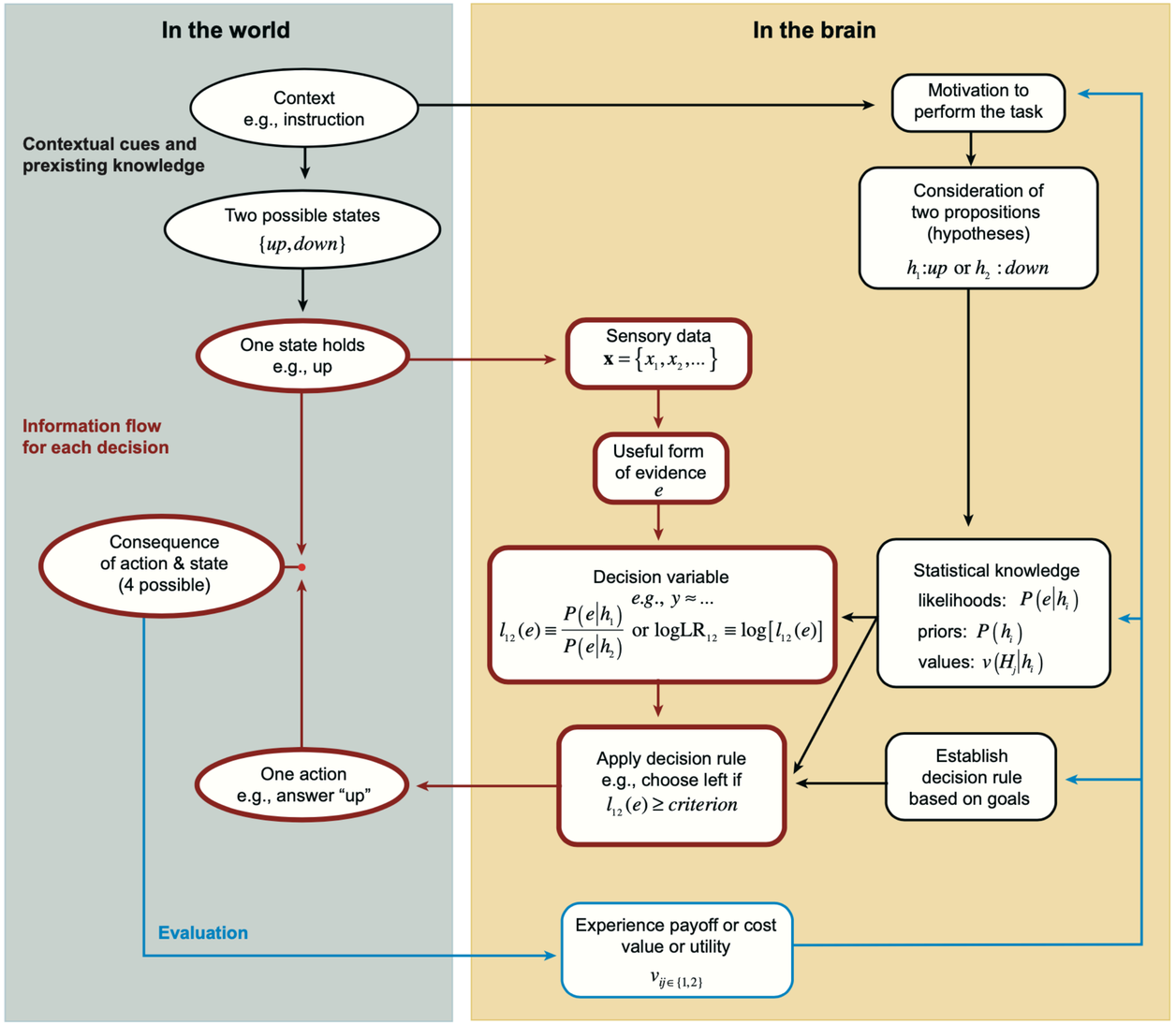
- Latimer, K. W., Yates, J. L., Meister, M. L., Huk, A. C., & Pillow, J. W. (2015). Single-trial spike trains in parietal cortex reveal discrete steps during decision-making. Science, 349(6244), 184-187.

Topics

- Accumulators in the cortex
- Is it really accumulation?

Accumulators in the cortex

Elements of making a decision



(Gold & Shadlen, 2007)

Serial evaluation of evidence

Sequential analysis framework

$$e_0 \rightarrow f_0(e_0) \Rightarrow \underset{or}{Stop}$$

$$\swarrow$$

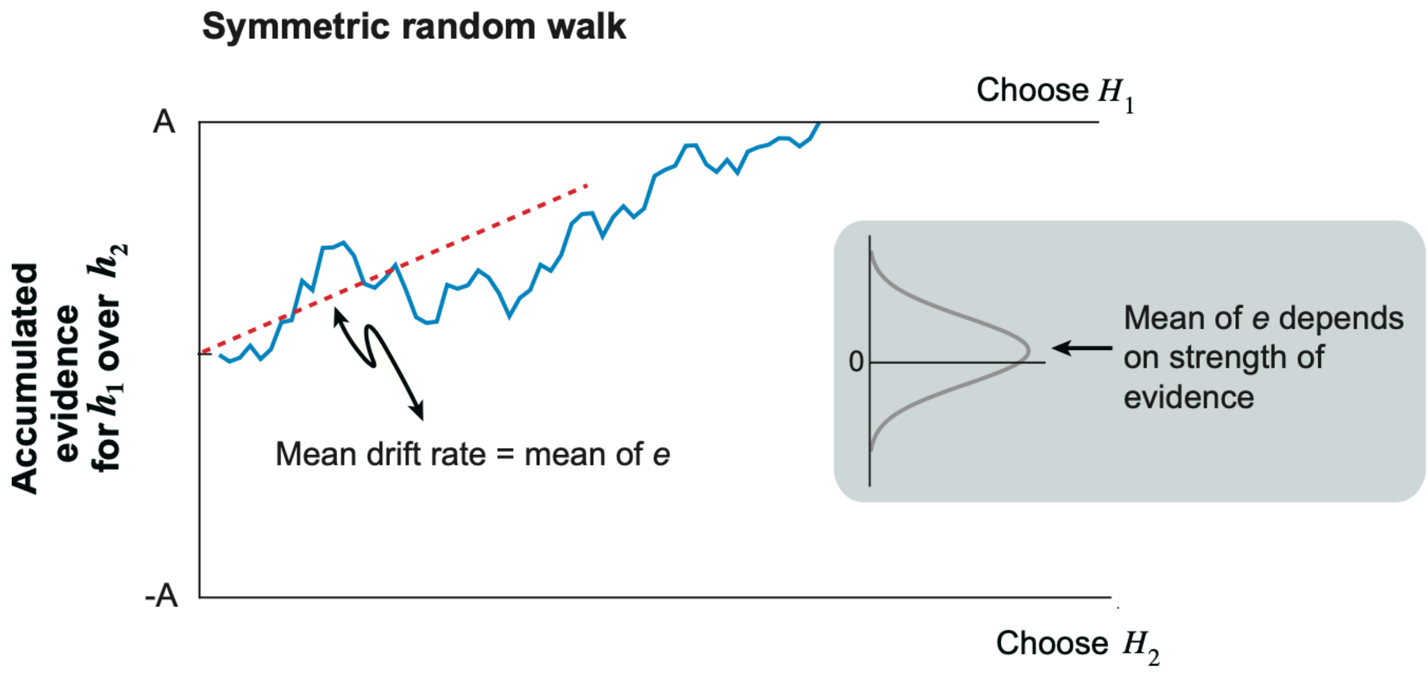
$$e_1 \rightarrow f_1(e_0, e_1) \Rightarrow \underset{or}{Stop}$$

$$\swarrow$$

$$e_2 \rightarrow f_1(e_0, e_1, e_2) \Rightarrow \underset{or}{Stop}$$

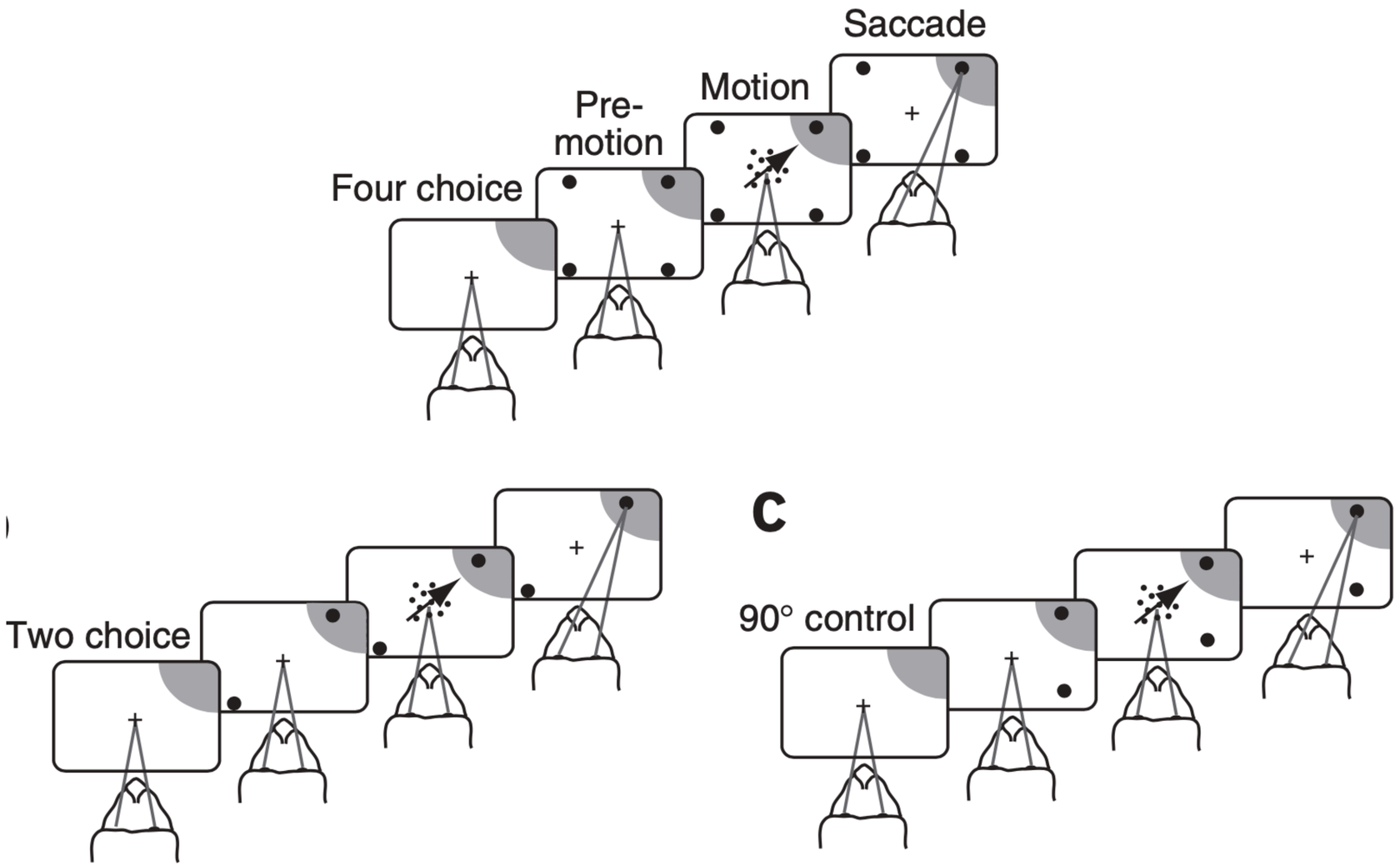
$$\vdots$$

$$e_n \rightarrow f_1(e_0, e_1, \ldots, e_n) \Rightarrow \ldots$$



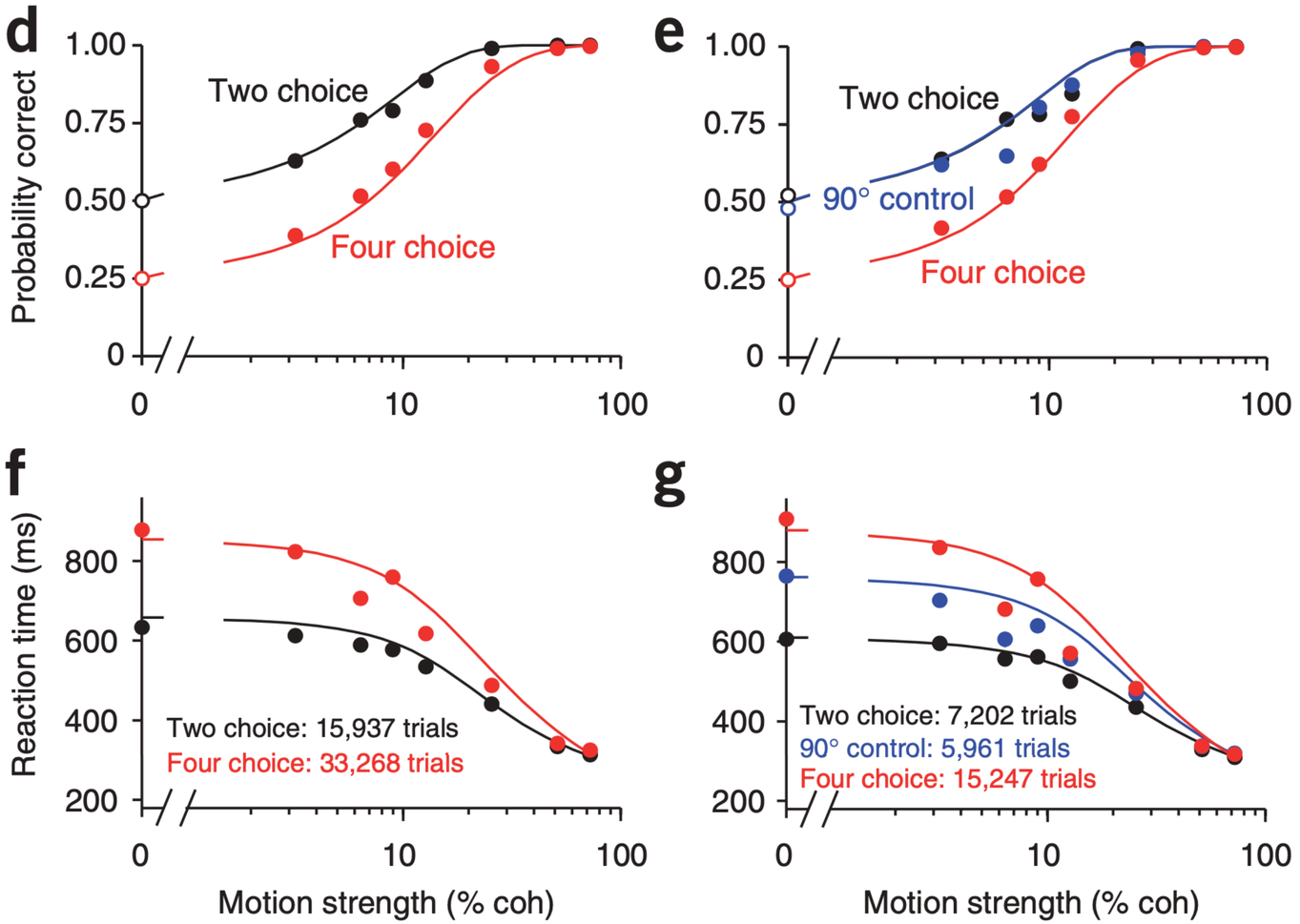
(Gold & Shadlen, 2007)

Multi-choice dot motion task



(Churchland et al. 2008)

Speed & accuracy

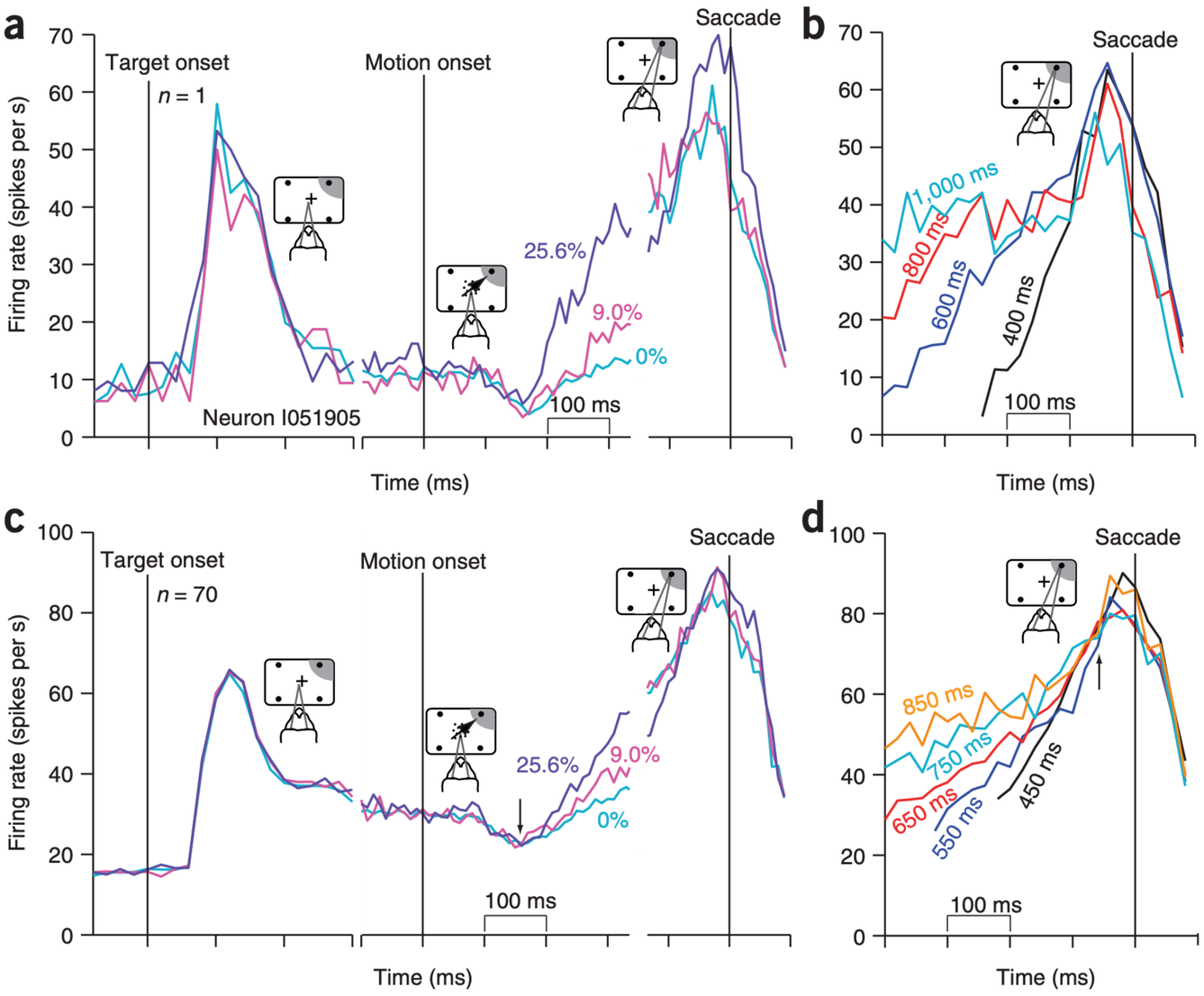


Decisions got faster and more accurate with:

1. Fewer options
2. More coherent evidence

(Churchland et al. 2008)

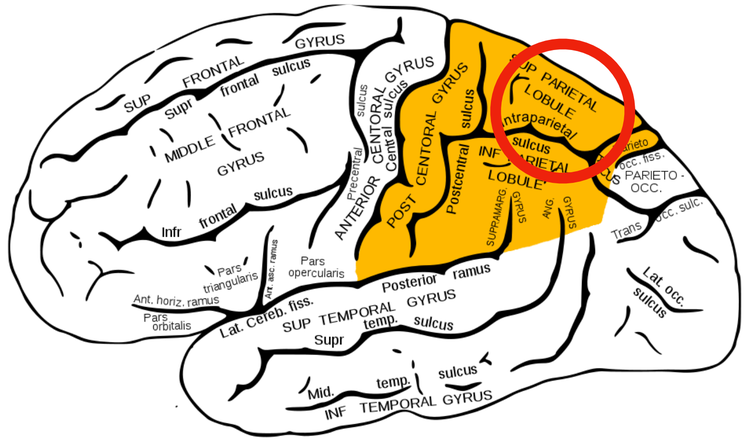
Ramping in the cortex



Single neuron

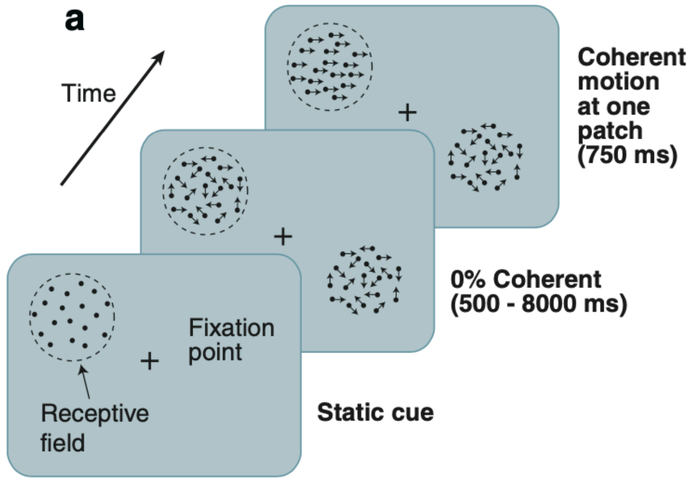
Population avg

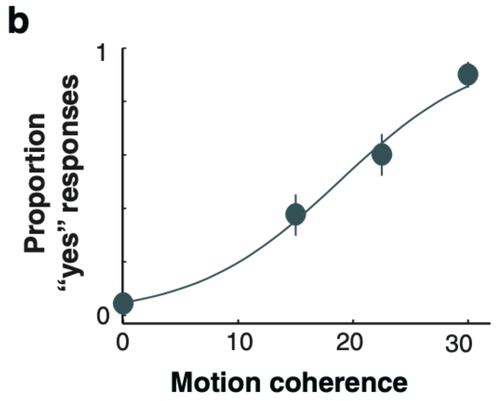
Firing rates of neurons in LIP respond like bounded accumulators.

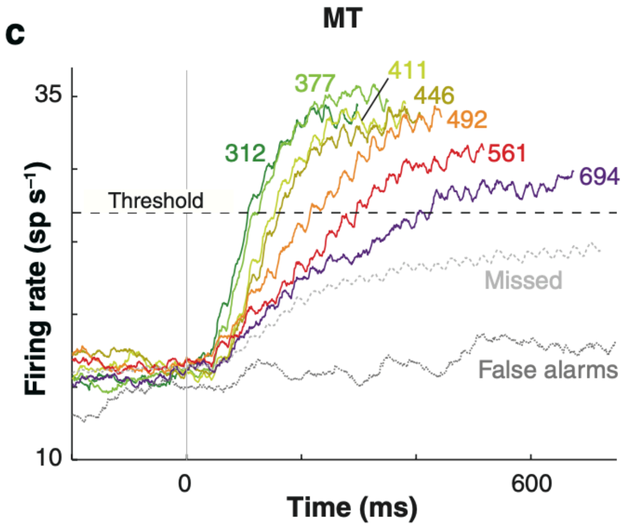


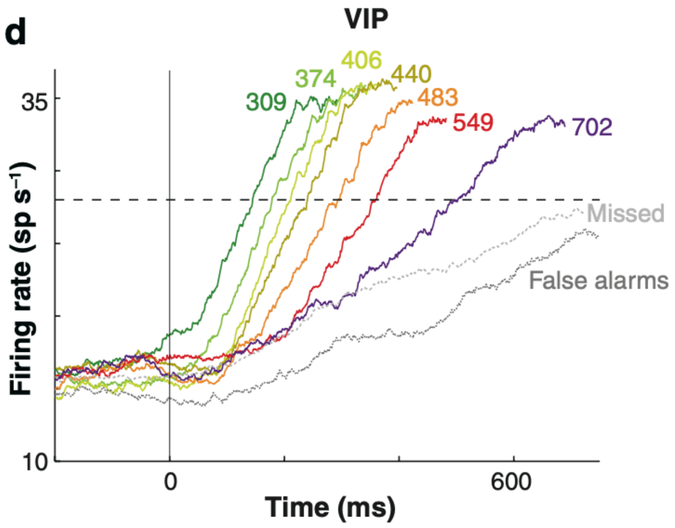
(Churchland et al. 2008)

Other accumulators

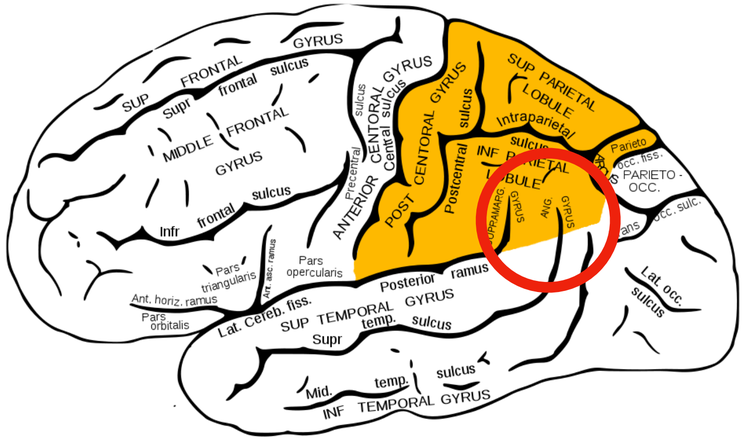








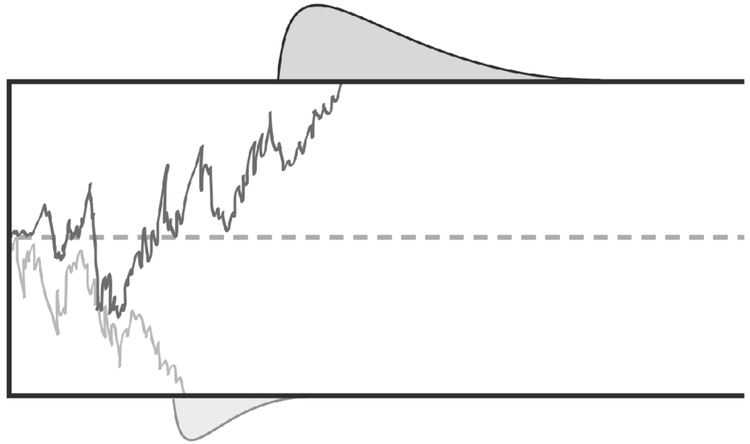
Areas that process visual motion also show accumulator-like dynamics.



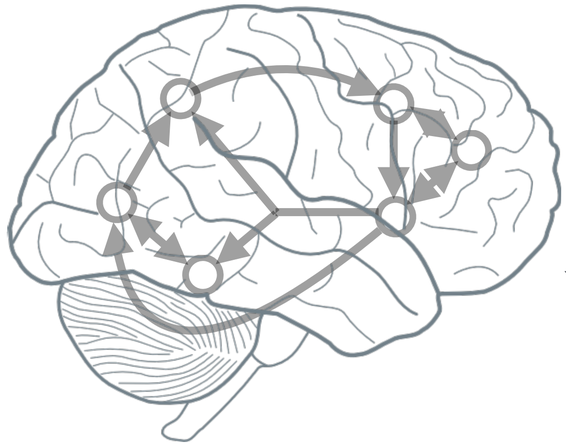
(Gold & Shadlen, 2007)

Assumptions?

Cognition
(process)



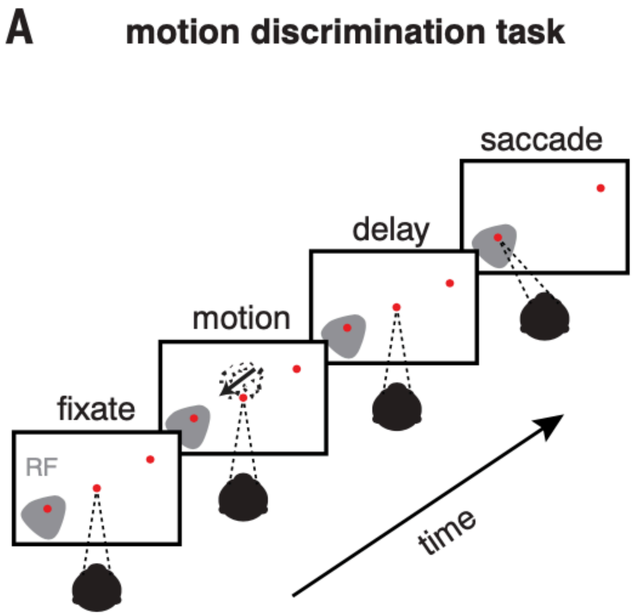
Neural Circuitry
(mechanics)



Isomorphism?

Is it really accumulation?

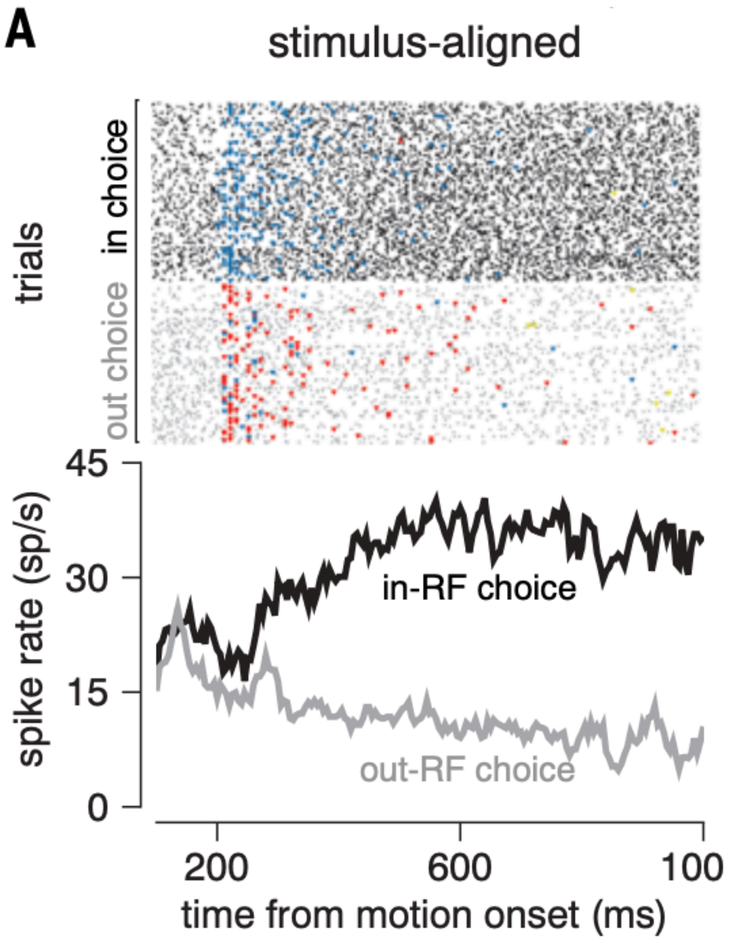
Rethinking accumulators



The ramping and stepping behavior will look identical when aligned to stimulus onset

(Latimer et al. 2015)

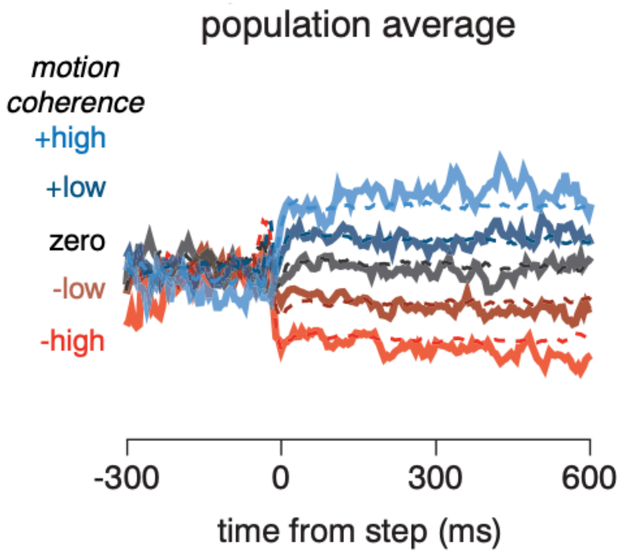
Same data, different analysis



Search routine to find “steps” in firing rates of neurons during the deliberation time.

(Latimer et al. 2015)

Accumulators vs steppers



Most neurons in LIP showed patterns largely consistent with the step model, though some showed ramping (accumulator effects) and some showed responses inconsistent with either model.

(Latimer et al. 2015)

Timeline of a controversy

TECHNICAL COMMENT

NEURONAL MODELING

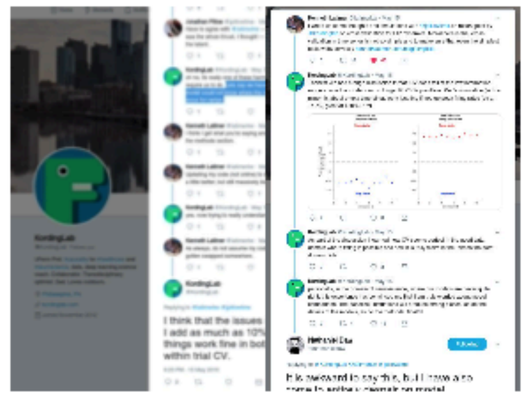
"OVER OUR DEAD CAREERS, IT RAMPS SO HARD!"

Michael N. Shadlen,[1*] Roozbeh Kiani,[2] William T. Newsome,[3] Joshua I. Gold,[4] Daniel M. Wolpert,[5] Ariel Zylberberg,[6] Jochen Ditterich,[7] Victor de Lafuente,[8] Tianming Yang,[9] Jamie Roitman[10]

"EVERYBODY SUCKS AT STATISTICS ...also LIP totally ramps"

Xuelong Zhao, Konrad P. Kording

May 4, 2018



"LIP DOESN'T EVEN RAMP!"

Kenneth W. Latimer,[1,2] Jacob L. Yates,[1,2] Miriam L. R. Meister,[2,3] Alexander C. Huk,[1,2,4,5] Jonathan W. Pillow[1,2,5,6*]

TECHNICAL RESPONSE

NEURONAL MODELING

"Super whack arguments you guys. Please retire"

Kenneth W. Latimer,[1,2,3] Jacob L. Yates,[1,2] Miriam L. R. Meister,[3] Alexander C. Huk,[1,2,4,5] Jonathan W. Pillow[1,2,5,6*]

"JK EVERYONE! ...sort of..."

Kenneth W. Latimer[1], Alexander C. Huk[2], Jonathan W. Pillow[3,*]

2015 ··· ▶ 2018

Take home message

- Churchland et al. show that averaged firing rates of cells tracks with the certainty of the evidence in making a decision.
- Latimer et al. show that, at the single neuron level, a subset of cells appear to show step-like properties instead of ramping.

Debate time!

Prompt: Given the mixture of results in the LIP (and other areas) as to whether cortical neurons express accumulator-like properties, should we abandon accumulator models for explaining how the cortex makes decisions?

Group A: Defend cortical accumulators

Group B: Reject cortical accumulators

Timeline: