A NEURODYNAMICAL MODEL OF MULTIPLE-CHOICE DECISION-MAKING WITH SIMULTANEOUSLY COMPETING EVIDENCES

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1. Introduction

Recent findings by Bollimunta and Ditterich (Bollimunta and Ditterich, 2011) in a three-alternative choice task suggest that a single variable, net-motion-strength (NMS), i.e. difference between evidence supporting one choice and mean evidence supporting the other alternatives, governs the decision process.
Their results generate a conflict: on the one hand it seems that they challenge a class of attractor networks (Wang, 2002) while on the other it can easily be reproduced by various diffution model implementations(Ditterich, 2006).

2. Experiment: Paradigm and Results

Two monkeys perform a three-alternative choice decision-making task with a random dot motion stimulus. Sensory evidence is manipulated independently for each of the three decision targets(Bollimunta and Ditterich, 2011).

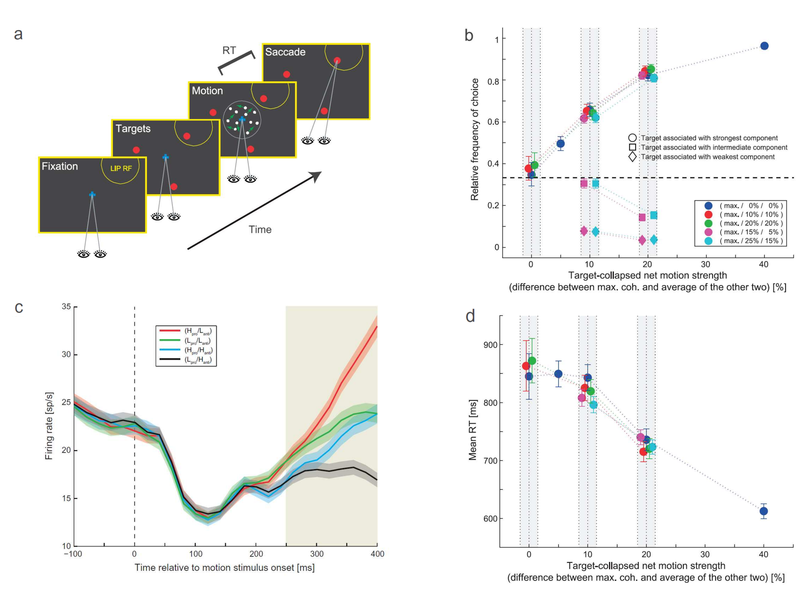

FIGURE 1: **Behavioural task scheme and results.** Behaviour is manipulated by the variable NMS, both when the coherence of the two weakest component is equal (symmetric trials) and when it is different (asymmetric trials), (adapted with permission from Bollimunta and Ditterich (2011)).

3. The Model

We make use of the attractor network described in Albantakis and Deco (2009):

- Neurons:
  - Noisy, leaky integrate-and-fire neurons with fast (AMPA) and slow (NMDA) synaptic dynamics.
- Pools and stimuli metaphor:
  - Stimulus noise is reduced proportionally when coherence increase and the noise is equally distributed among the three pools.
  - Pools L/R/U = saccade to the left/right/up.
  - $\lambda_{L,R,U}$ = motion coherence towards left, right or upper target
  - $\lambda_L + \lambda_R + \lambda_U$ = constant
- Selective pools R, L and U engage in a competition biased by the input.

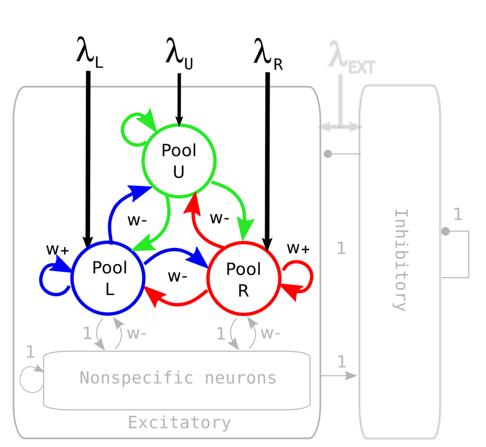

FIGURE 2: **Network scheme.**

4. Results

Neural Dynamics

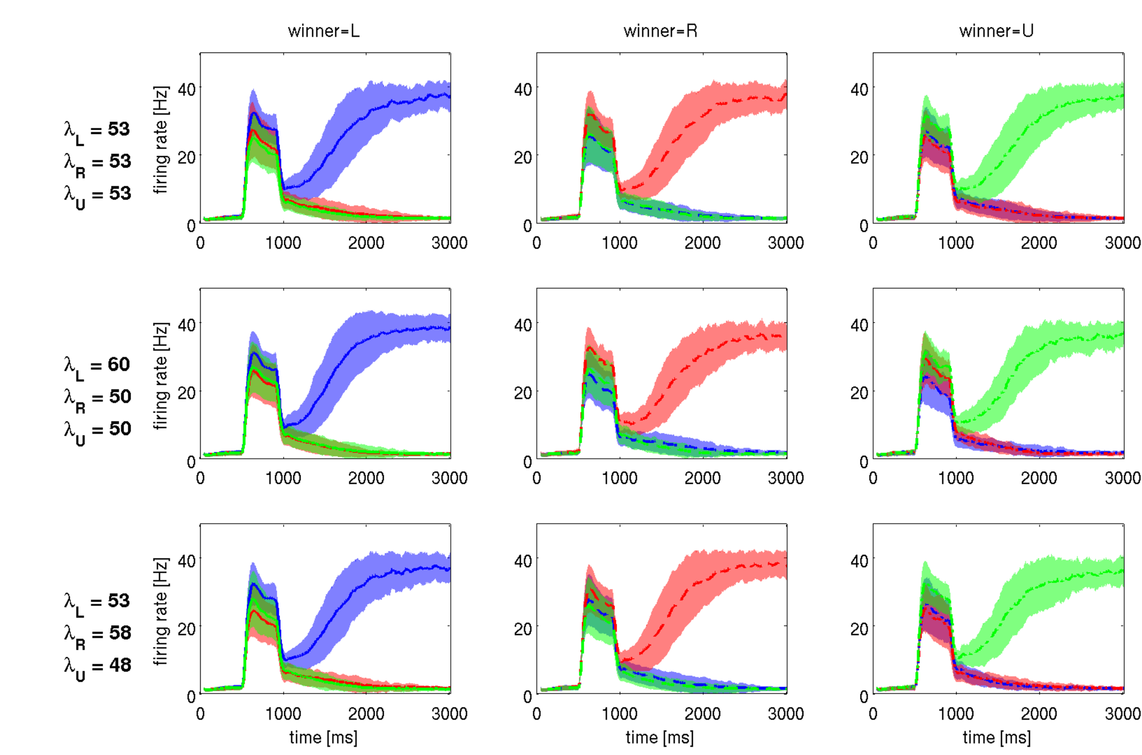

FIGURE 3: **Average firing rates.** Lines represent average firing rate over all trials. Shaded area represents standard deviation. Colors according to network scheme.

Behavior

- The model reproduces accurately psychophysical data, thus allowing us to explain behaviour in terms of its neural processes.
- NMS is not able to explain behaviour when asymmetry increases (green dots).

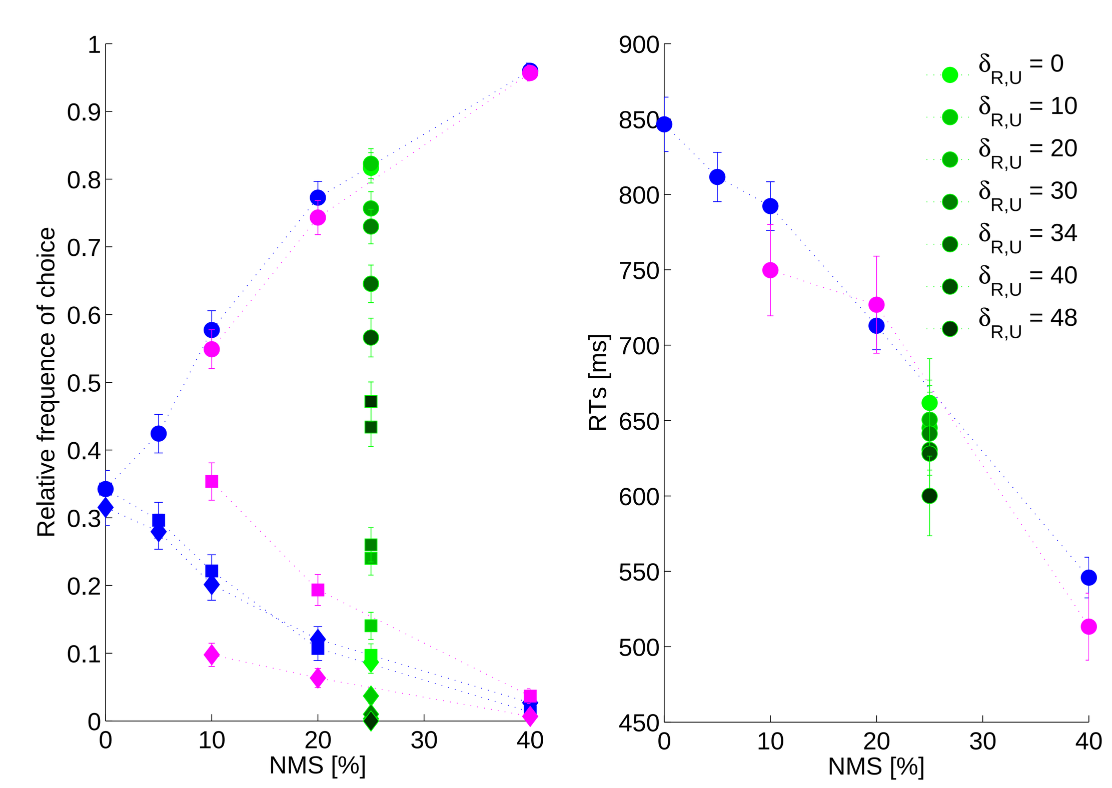

FIGURE 4: **The model reproduces monkey behavior.** Blue (magent) lines depict frequency of choice for one target in symmetric (asymmetric) trials (symbols as in FIGURE 1). Green points represent frequency of choice for trials with increasing asymmetry for NMS = 25 ($\delta_{R,U} = \lambda_R - \lambda_U$).

- Performance decreases as a function of asymmetry.
- Surprisingly reaction times get faster when asymmetry increases (and decision is more difficult).

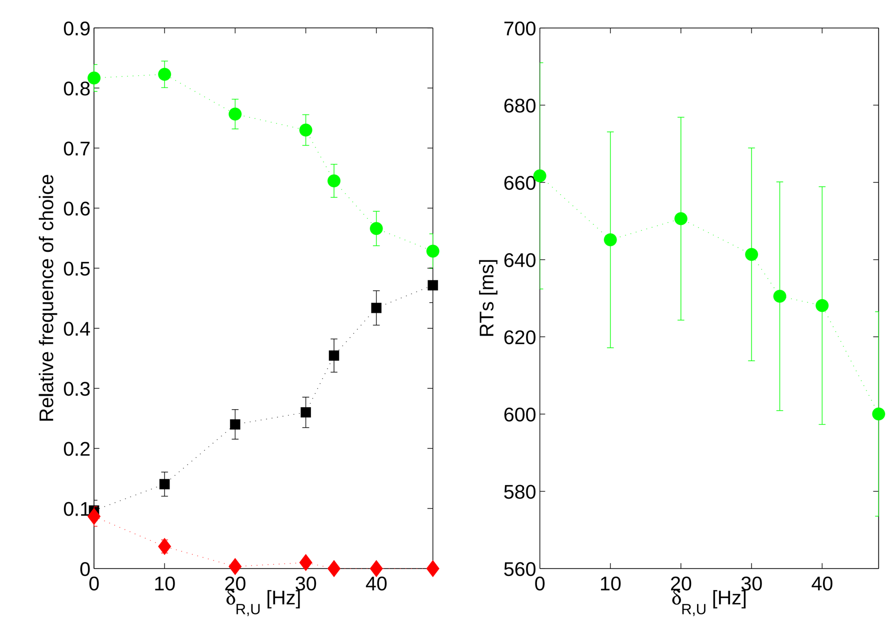

FIGURE 5: **Model predicts a different behaviour for highly asymmetric trials.** Green (black, red) lines represent probability of chosing target one (two, three).

4. Work in Progress

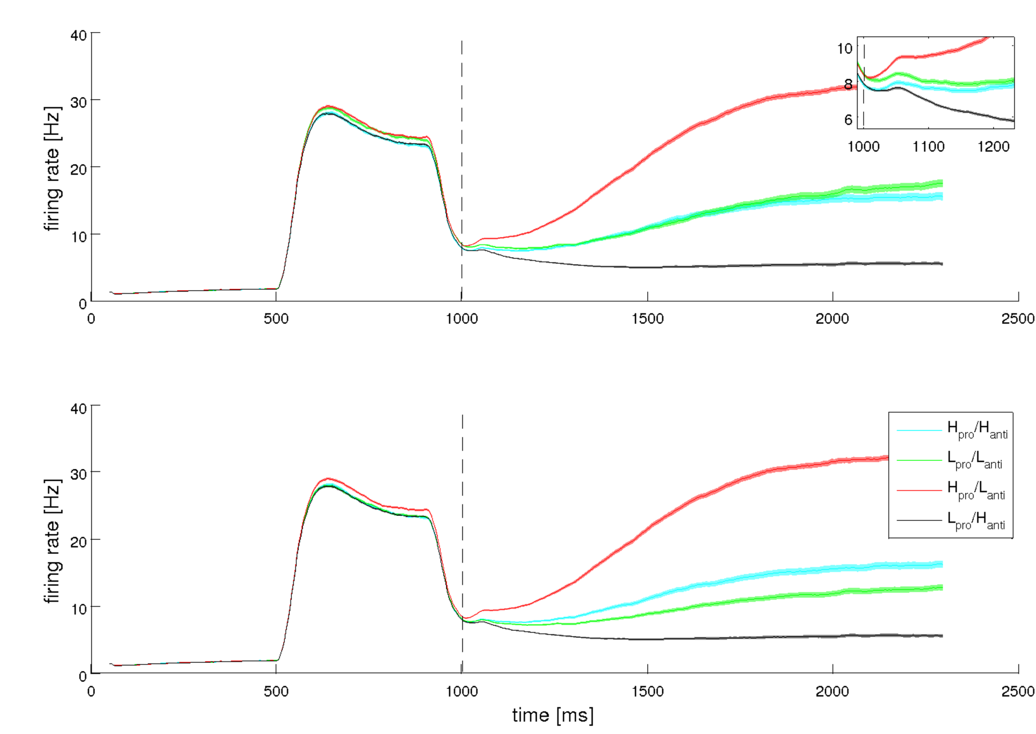

FIGURE 6: **Average firing rates** when trials are sorted as in FIGURE 1c.

Conclusions

- NMS is not able to fully explain behavior
- Performance and RTs decreases when asymmetry increases

References

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