A Spiking Independent Accumulator Model for Winner-Take-All Computation

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Motivation

- Investigate WTA mechanisms in the context of neurally plausible cognitive modelling
- Implement using spiking neurons
- Explore the effect of noisy inputs on stable decision making
- Allow for integration into larger scale networks

Neural Engineering Framework

- *Representation* in spiking neurons defined by encoding $a_i(t) = G_i\left[a_i e_i x(t) + J_i^{\text{bias}}\right]$ and decoding $\hat{x}(t) = \sum_i d_i\left[(a_i * h)(t)\right]$
- *Transformation* by decoding weights d_i minimizing $E_{f(x)} = |f(x) - \hat{x}|$
- *Dynamics* by recurrent transformation

$$\frac{\partial x}{\partial t} = g(x) \quad \Rightarrow \quad f(x) = \tau_s g(x) + x$$

Definitions

- **Clear:** single output above 0.15, stable over at least 1 s
- **Correct:** output corresponds to strongest input
- **Input magnitude:** Magnitude of target input
- **Target separation:** Separation of target input from non-target inputs

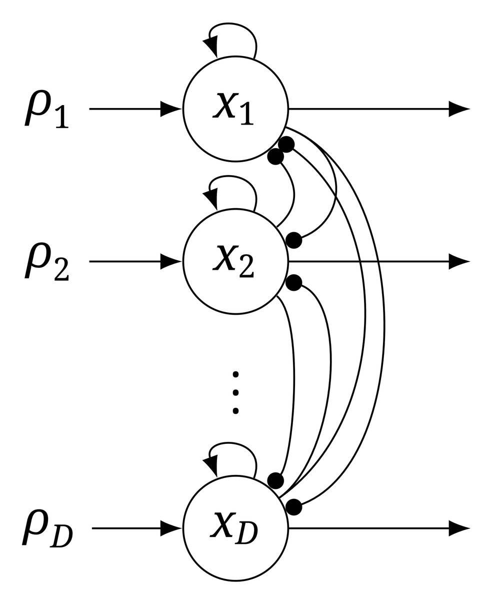
Conclusions

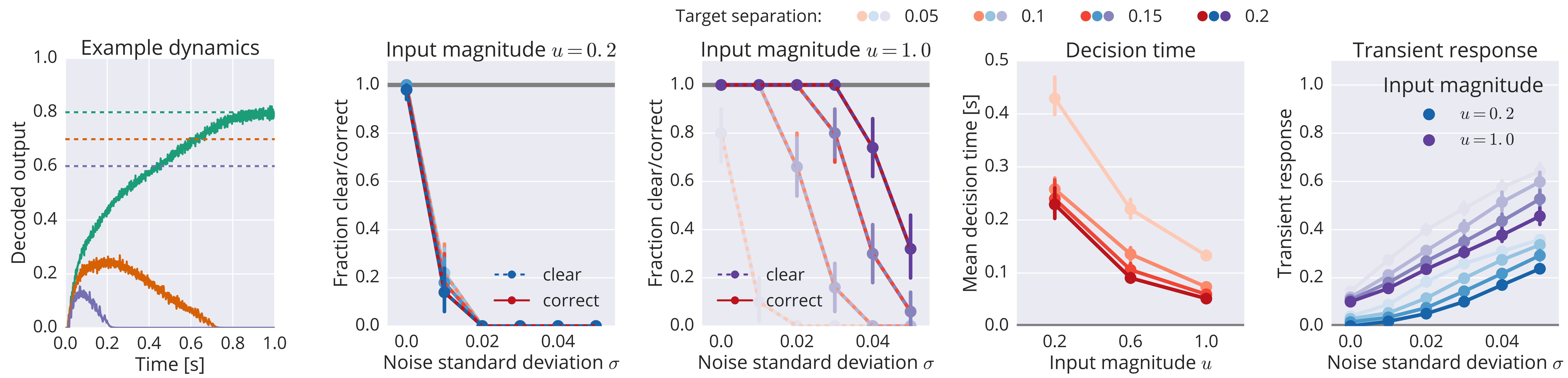
- The two WTA mechanisms are best suited for different purposes
- LCA network:
  - Reacts more quickly
  - If stable decision is reached, it will be correct
  - Output can be unstable in noisy conditions
- IA network: will eventually give a stable output, but it might not be the correct one

Leaky, Competing Accumulators (LCA)

$$\frac{\partial x_i}{\partial t} = \left(\rho_i - k x_i - \beta \sum_{j \neq i} x_j\right) \frac{1}{\tau},$$
$$x_i \geq 0$$

Usher, M., & McClelland, J. L. (2001). The time course of perceptual choice: THe leaky, competing accumulator model. *Psychological Review*, 108(3), 550–592.





Independent Accumulators (IA)

$$\bar{x}_i := \Theta(x_i - \vartheta),$$
$$\frac{\partial x_i}{\partial t} = \rho_i \frac{1}{\tau_1} + \left(\bar{x}_i - \beta \sum_{j \neq i} \bar{x}_j\right) \frac{1}{\tau_2},$$
$$x_i \geq 0$$