



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 $a_i(t) = G_i [a_i e_i x(t) + f_i^{\text{bias}}]$ and decoding $\hat{x}(t) = \sum_i d_i [(a_i * h)(t)]$
- Transformation* by decoding weights d_i minimizing $E_{f(x)} = |f(x) - \hat{x}|$
- Dynamics* by recurrent transformation
$$\frac{\partial x}{\partial t} = g(x) \Rightarrow f(x) = \tau_s g(x) + x$$

Benchmarks

- Ability to provide a clear output (single output above 0.15, stable over at least 1 s)
- Correctness (output corresponds to strongest input)
- Time required to reach a decision
- Transient outputs before final decision is reached

Conclusions

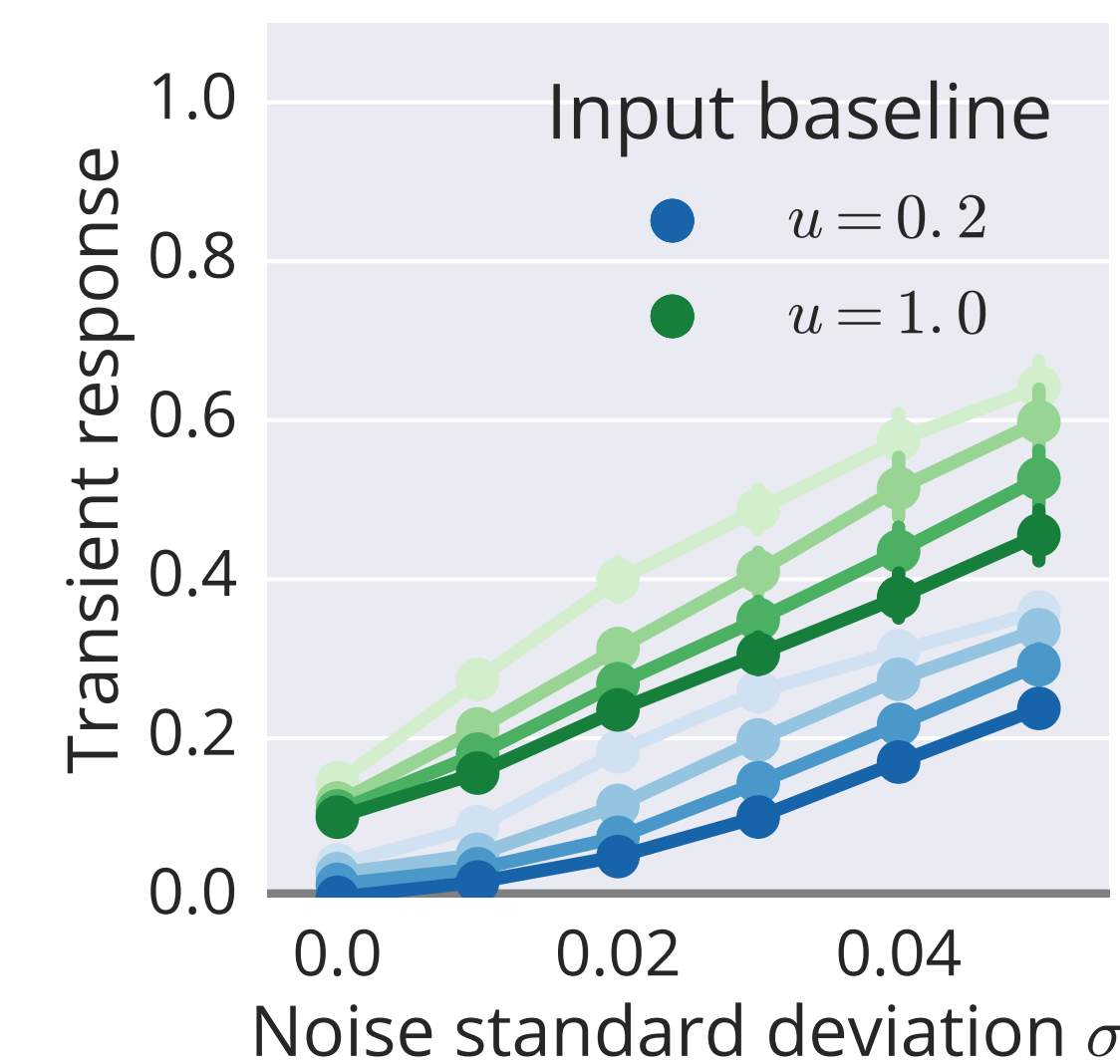
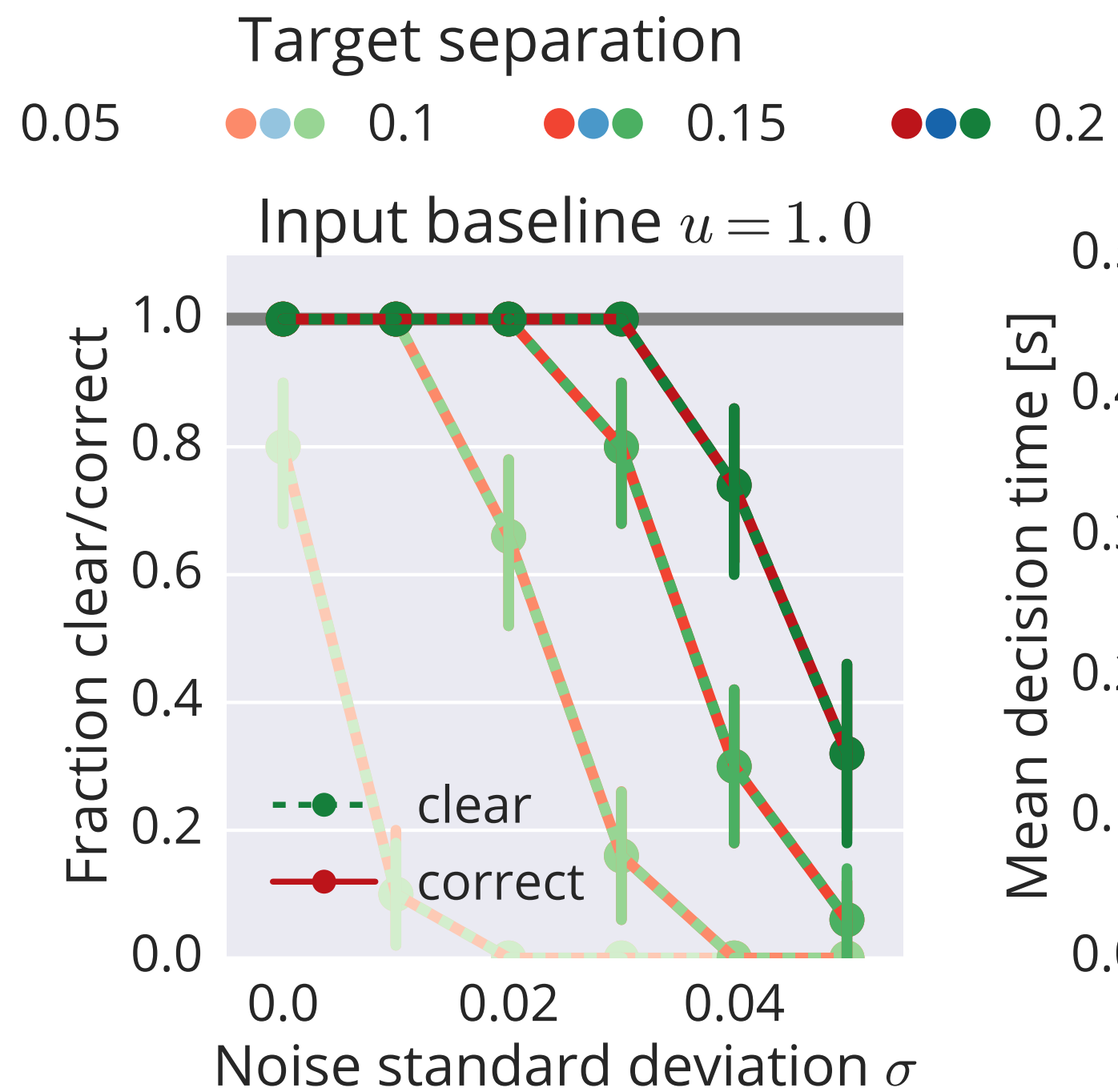
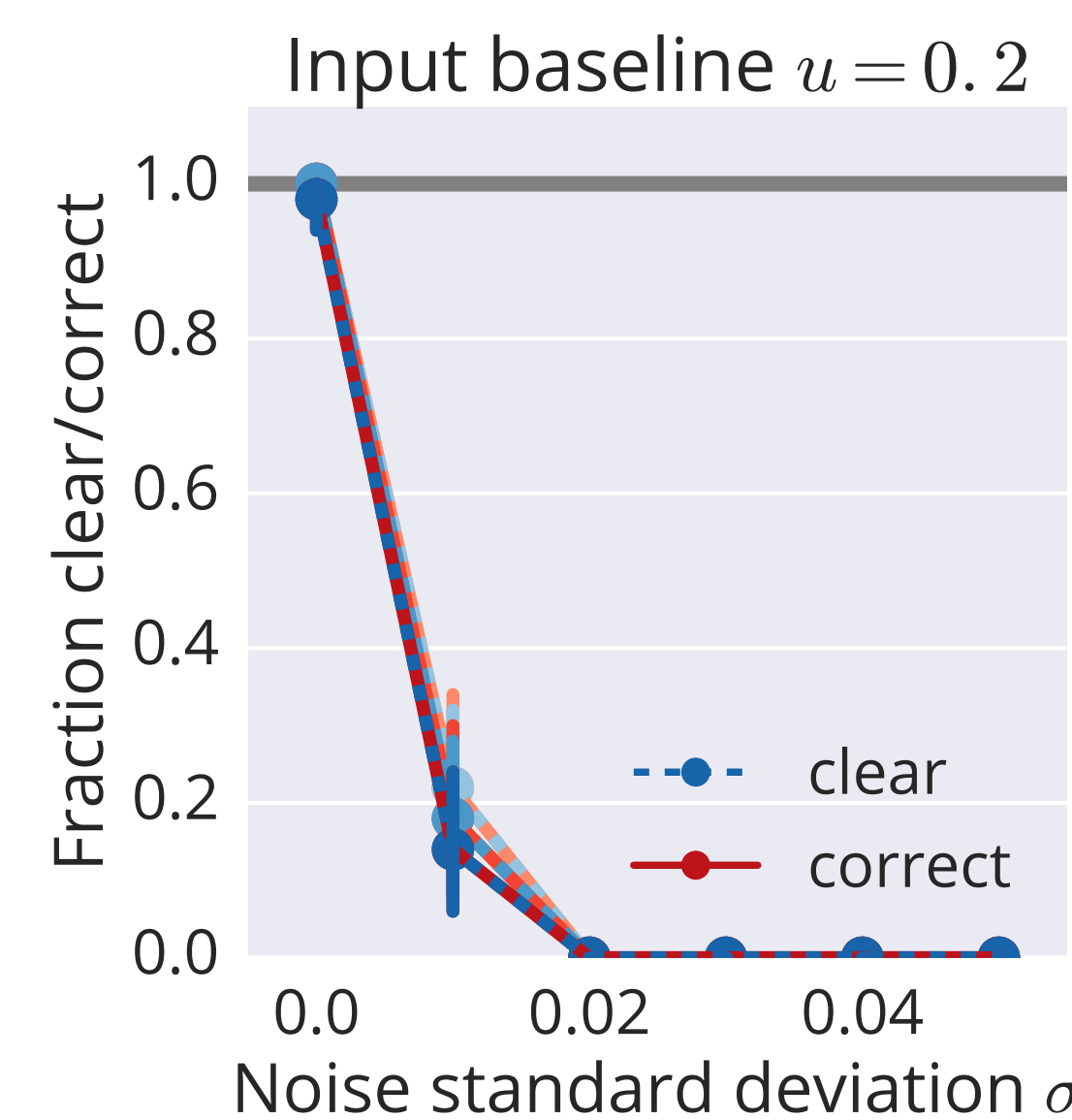
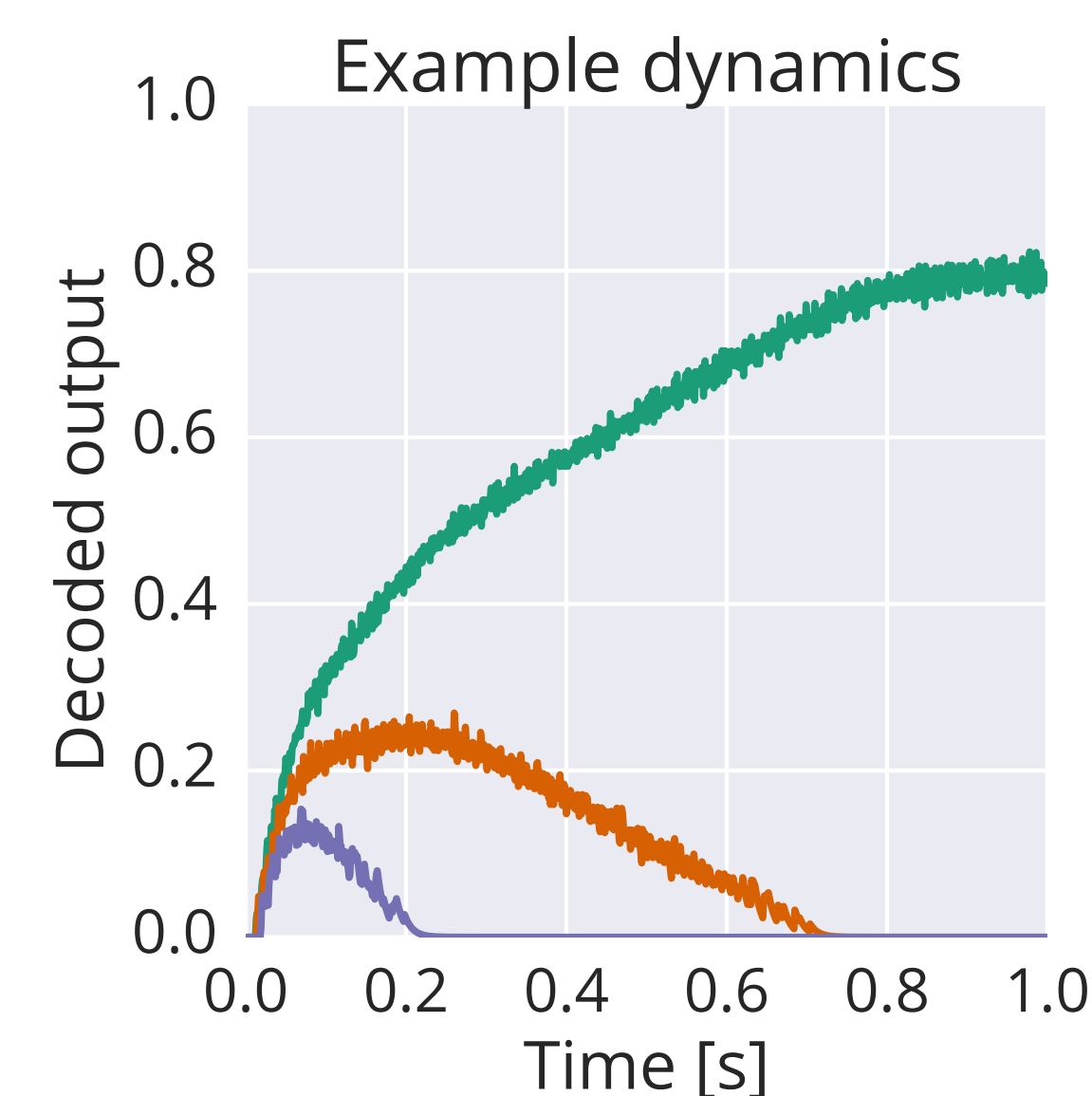
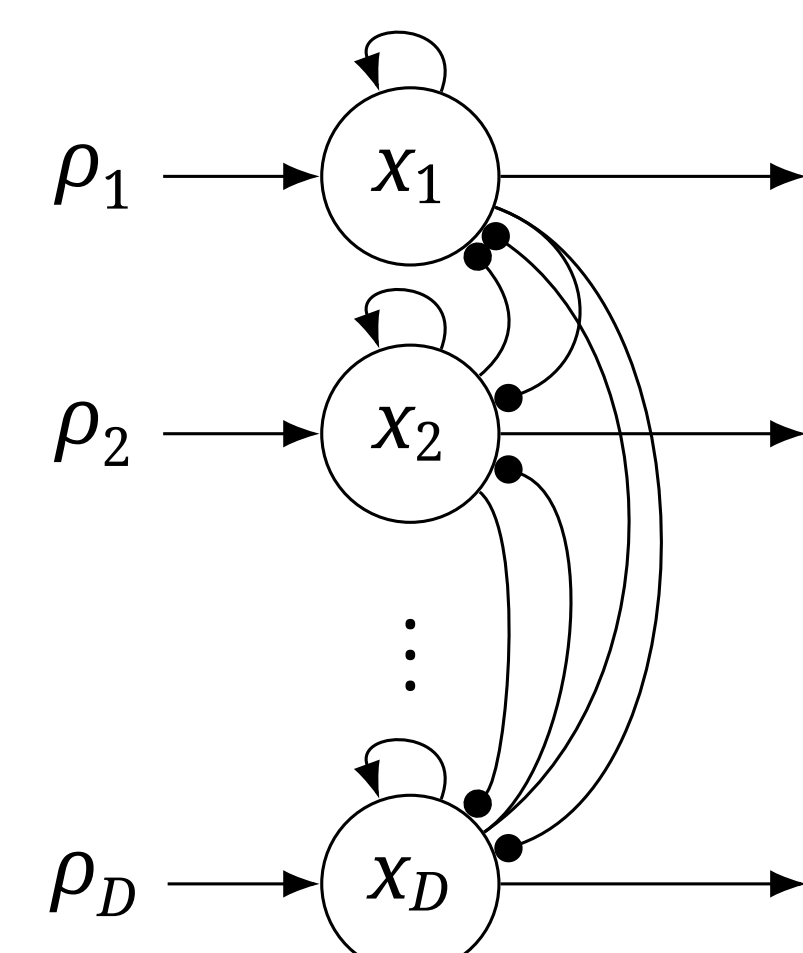
- The two WTA mechanisms are best suited for different purposes
- LCA network:
 - Reacts more quickly
 - If stable decision is reached, it will be correct
 - Output can be unstable in noisy conditions
- IA network: will eventually give a stable output, but it might not be the correct one

Leaky, Competing Accumulators (LCA)

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

$$x_i \geq 0$$

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)

$$\bar{x}_i := \Theta(x_i - \vartheta),$$

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

$$x_i \geq 0$$

