Neurons can track context and outcomes in the pursuit of goals

**Outcome:** Researchers from CELEST, an NSF Science of Learning Center, have found that cellular activity in a primate frontal brain region known as the Anterior Cingulate Cortex (ACC) reflects context, and unexpected outcomes of prior responses, more than conflict between competing “cognitive” representations.

**Impact/benefits:** In a dynamically changing world, we must learn to sustain attention to types of information that have current relevance for successful achievement of our goals. This research is important for clarifying how, at the single neuron level, the ACC monitors and helps sustain our attention in the pursuit of goals.

**Explanation:** Previous studies have postulated that medial prefrontal cortices, including ACC, are important for monitoring information about our own performance and internal states. Such monitoring enables strategic adjustments to attention, information processing, and decisions among actions, especially under cognitively demanding conditions. Some such adjustments are mediated by strong projections from ACC to the DLPFC (Dorsal-Lateral Prefrontal Cortex), which contributes to working memory and other aspects of cognitive control, including sustained and selective attention. However, it was not previously known whether neurons in the ACC tracked (1) contexts that cue responses, (2) the conflict that arises when such contexts happen to cue incompatible rather than congruent responses, (3) unexpected outcomes of previous responses (which often follow incorrect resolutions of conflict), or all three. We find that the region of ACC studied does indeed track context and outcomes of previous responses, but not conflict between contexts that cue alternative responses.

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**Models of Task Switching**

**Conflict Model**

- Representation #1
- ACC
- DLPFC
- “Conflict”

The conflict model hypothesizes the ACC detects conflict between competing representations and signals the DLPFC to resolve the conflict.

**Reinforcement Model**

- Response
- Outcome
- ACC
- DLPFC
- “Unexpected Outcome”

The reinforcement model hypothesizes the ACC learns to associate responses and outcomes (reward or non-reward) and signals the “surprise” of unexpected response and outcome combinations — a prediction error — to DLPFC.

*Researchers have shown that the reinforcement model is a better model for how we maintain our attention to goals in a dynamically changing world.*

*Image Credit: Eric Denovellis/Boston University*