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# A brain-wide, trial- and time-dependent determ synergizes with within-trial noise to time self-ir

## European Neuroscience Institute Göttingen (ENI-G)

Deciding when to act in the absence of external cues is essential for exploration, learning, and survival. Yet the neural mechanisms underlying such decisions remain controversial, with current views favoring either deterministic or stochastic underpinnings. Here, large-scale neuronal populations were simultaneously recorded across cortical, thalamic, pallidal, and cerebellar regions as mice performed self-initiated voluntary actions. Action onset timing was predictable from firing patterns up to several seconds in advance with predictions correlated across regions, demonstrating a prominent deterministic drive that spans regions. Computational modeling indicated that this drive has an initial value and rate that vary trial-by-trial, and the rate increases within trials. Although the deterministic drive is sufficient to trigger action, noise within trials also contributes to setting action timing. Therefore, discrete (across-trial) and continuous (within-trial) sources of variability synergize to time self-initiated actions. This synergy is observed brain-wide, suggesting a distributed decision-making process rather than a hierarchical, modular one

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