How criticality of visuo-motor control behaviour depends on task objective.

Abstract

When humans perform closed-loop control tasks like standing upright or balancing a stick, their behavior exhibits spatiotemporal scaling suggesting operation close to a critical point. Prominently, control errors during balancing are power-law distributed. A possible explanation is self-tuning of the control system to a critical point due to the annihilation of local information by adaptive predictive control.

A simple model based on this principle was shown to reproduce many experimental findings. This model makes several predictions, including that the underlying neuronal control system continues to be adaptive even when the controlled system itself is stationary. This seemingly irrational behavior is caused by the controller trying to eliminate local random trends in its interaction with the controlled system over short time scales close to its reaction time.

We performed virtual balancing experiments to test the theoretical predictions. Most notably, we found the subjects’ behavior to be dramatically dependent on the utilized reward function. The existing model was found to be an excellent description for subjects trying to minimize mean squared controller-target distances. Given a different reward function, subjects displayed other solutions to the balancing problem that have not been reported before. Some of these solutions which do not exhibit power-law fluctuations can be explained by simple modifications to the existing model. Our results provide important constraints for possible neuronal implementations of visuo-motor control.

Further Reading

The theoretical results underlying our most recent experiments are presented in: