

FORECASTING SENSORIMOTOR ADAPTABILITY FROM BASELINE INTER-TRIAL CORRELATIONS

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INTRODUCTION

One of the greatest challenges surrounding adaptation to the spaceflight environment is the large variability in symptoms, and corresponding functional impairments, from one crewmember to the next. This renders preflight training and countermeasure development difficult, as a “one-size-fits-all” approach is inappropriate. Therefore, it would be highly advantageous to know ahead of time which crewmembers might have more difficulty adjusting to the novel g-levels inherent to spaceflight. Such knowledge could guide individually customized countermeasures, which would enable more efficient use of crew time, both preflight and inflight, and provide better outcomes. The primary goal of this project is to look for a baseline performance metric that can forecast sensorimotor adaptability without exposure to an adaptive stimulus. We propose a novel hypothesis that considers baseline inter-trial correlations, the trial-to-trial fluctuations in motor performance, as a predictor of individual sensorimotor adaptive capabilities. To-date, a strong relationship has been found between baseline inter-trial correlations and adaptability in two oculomotor systems [1,2]. For this project, we will explore an analogous predictive mechanism in the locomotion system.

METHODS

Baseline Inter-trial Correlations: Inter-trial correlations specify the relationships among repeated trials of a given task that transpire as a consequence of correcting for previous performance errors over multiple timescales. We can quantify the strength of inter-trial correlations by measuring the decay of the autocorrelation function (ACF), which describes how rapidly information from past trials is “forgotten.” Processes whose ACFs decay more slowly exhibit longer-term inter-trial correlations (longer memory processes), while processes whose ACFs decay more rapidly exhibit shorter-term inter-trial correlations (shorter memory processes). Longer-term correlations reflect low-frequency activity, which is more easily measured in the frequency domain. Therefore, we use the power spectrum (PS), which is the Fourier transform of the ACF, to describe our inter-trial correlations. The decay of the PS yields a straight line on a log-log frequency plot, which we quantify by $\beta = -$ (slope of PS on log-log axes). Hence, β is a measure of the strength of inter-trial correlations in the baseline data. Larger β values are indicative of longer inter-trial correlations.

Experimental Approach: We will begin by performing a retrospective analysis of treadmill-gait adaptation data previously collected by Dr. Bloomberg and colleagues. Specifically, we will quantify the strength of inter-trial correlations in the baseline step cadence and heart rate data and compare it to the locomotor adaptability performance results already described by these investigators. Incorporating these datasets will also allow us to explore the applicability of (and potential limitations surrounding) the use of β in forecasting physiological performance. We will also perform a new experiment, in which β will be derived from baseline data collected during over-ground (non-treadmill) walking, which will enable us to consider locomotor performance, through the parameter β , under the most functionally-relevant, natural gait condition. This experiment will incorporate two baseline and five post-training over-ground locomotion tests to explore the consistency and potential adaptability of the β values themselves.

HYPOTHESES

We hypothesize that the strength of baseline inter-trial correlations of step cadence and heart rate will relate to locomotor adaptability. Specifically, we anticipate that individuals who show weaker longer-term inter-trial correlations in baseline step cadence data will be the better adaptors, as step cadence can be modified in real-time (i.e., online corrections are an inherent property of the locomotor system; analogous to results observed in the VOR [1]). Conversely, because heart rate is not altered mid-beat, we expect that individuals who demonstrate stronger longer-term correlations in heart rate will be the better adaptors (analogous to results observed in the saccadic system [2]).

CONCLUSIONS

At the conclusion of this project we hope to uncover a baseline predictor of locomotor adaptability. If our hypotheses hold true, our results will demonstrate that the temporal structure of baseline behavioral data contains important information that may aid in forecasting adaptive capacities. The ability to predict such adaptability in the sensorimotor system has significant implications for spaceflight, where astronauts must adjust their motor programs following a change in g-level to retain movement accuracy.

REFERENCES

- [1] Beaton KH, Wong AL, Lowen S, Shelhamer M (2014) *In Process*.
- [2] Wong AL, Shelhamer M (2014) *J Neurophysiol* 111, 2084-2093.