

Alteration of the Direction of Throwing; Multiple Processes of Adaptation

Hugo Bruggeman¹, Chrstine E. Eid¹, Herbert L. Pick Jr.¹ & John J. Rieser²

¹Spatially Coordinated Behavior Laboratory, University of Minnesota ²Vanderbilt University

Background

Studies using an adaptation paradigm find adaptation to either a visual or mechanically distorted environment. Since these studies differ in the nature of the distortion, they produce a distinct adaptation, suggesting that movements are organized at multiple levels. However, few manuscripts report multiple processes of adaptation. We found evidence for multiple processes of adaptation for throwing movements.

Previous Studies

Rationale. Participants are seated on the periphery of a rotating carousel (radius of 1.5m, angular velocity of 7.5 rpm) and throw underhanded at a directly opposite target. We hypothesized that participants would miss the target if they did not anticipate the effects of both their tangential velocity (V_T) and the displacement of the target (ΔT) (I).

- We call such a distortion an alteration of the perceptual event since the property of the distortion does not involve a direct manipulation of the visual field nor the motor field.

Design. Studies had a pretest, experimental manipulation and posttest phase (II).

Results. On the carousel, participants initially made significant errors but gradually adjusted until their throws became nearly accurate.

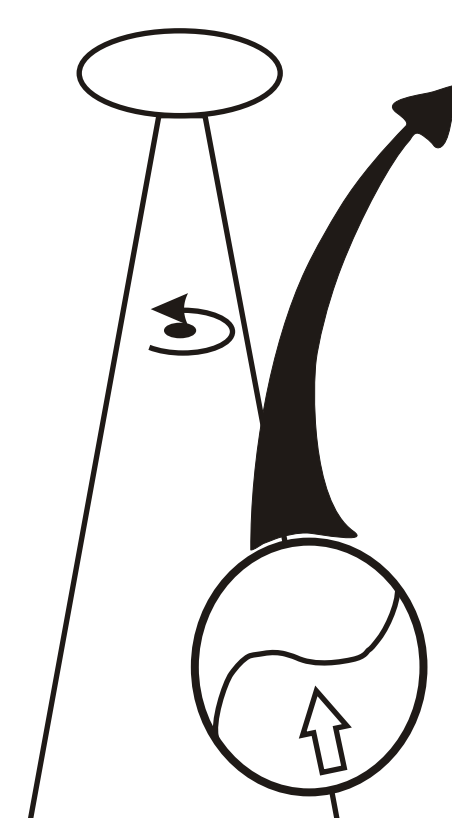
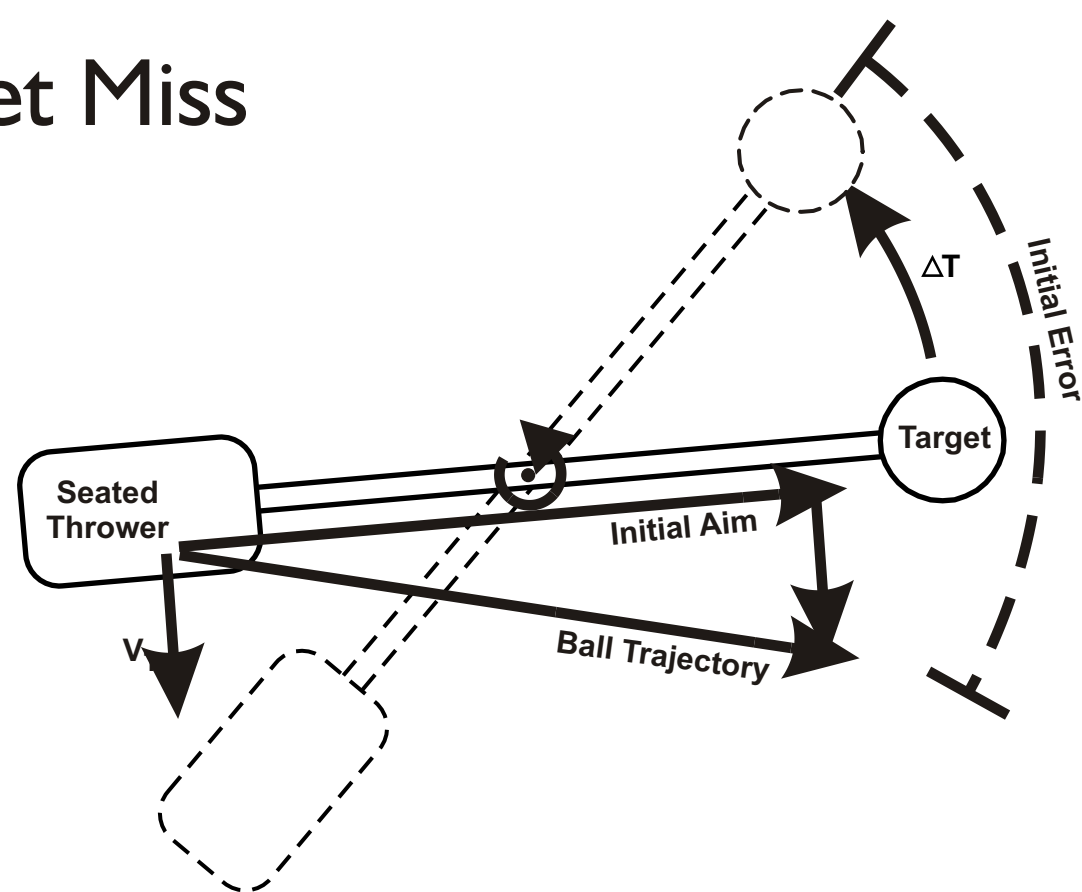
- This adaptation reliably alters the direction of underhand throwing during the posttest measured as a SHIFT from pretest. This SHIFT decays over test trials from 5.1° to an asymptote of about 3.1° (III).

- An additional study confirmed that, after a 30-minute period -filled with completing a questionnaire-, the SHIFT averaged 3.1° (III).

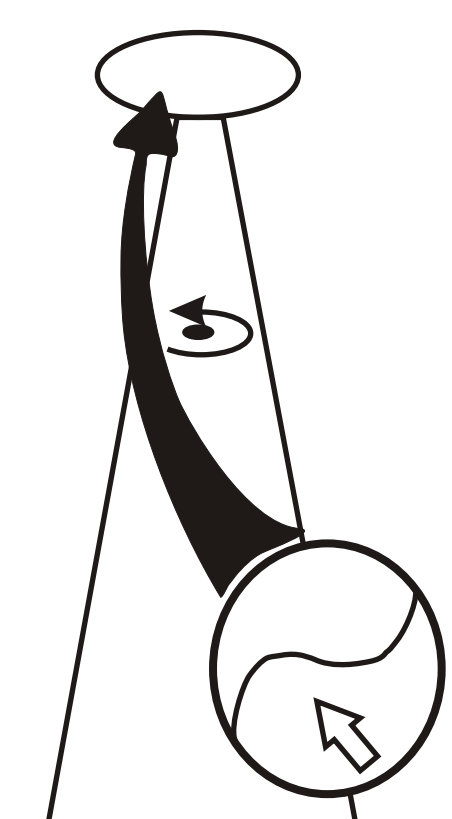
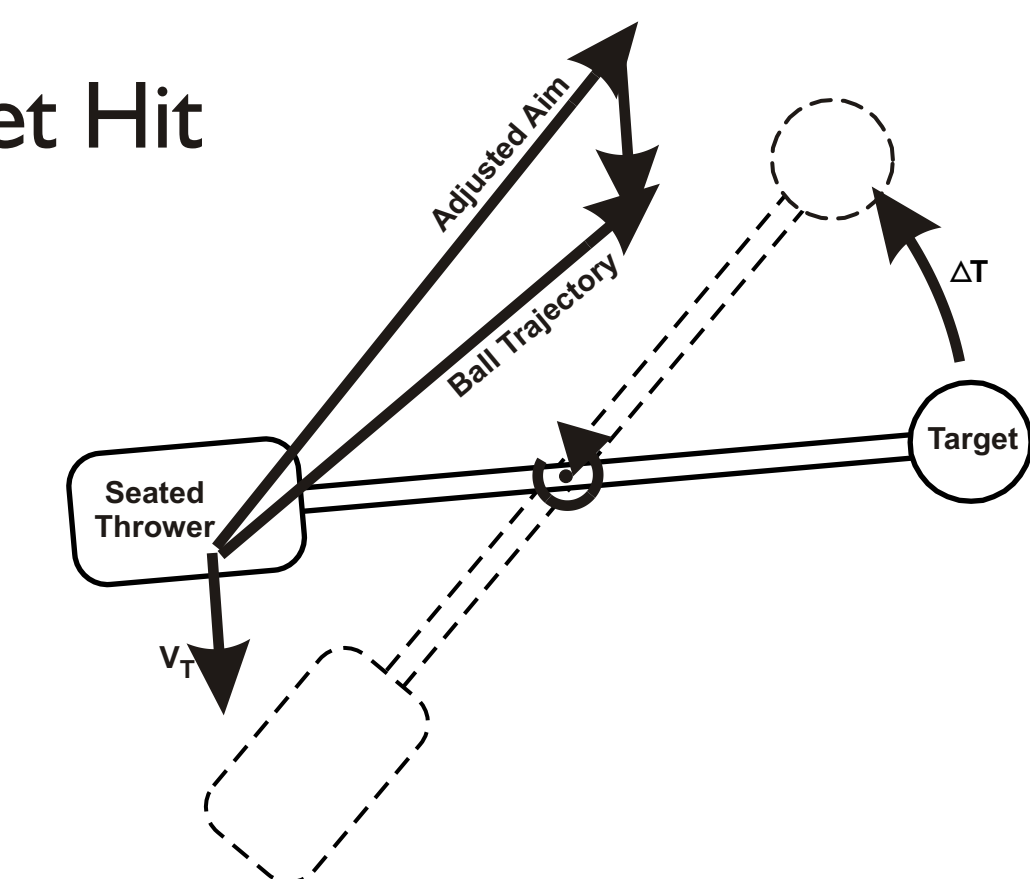
I: Target Miss & Target Hit

Top view (left) and view by participant (right)

Target Miss



Target Hit



Present Study

Research Question. Could the decay in SHIFT be related to adaptation to the Coriolis force? On the carousel, movements are subjected to a Coriolis force that is a product of the speed of rotating and the velocity of the movements (Equation). Lackner and DiZio (1994) showed adaptation to the Coriolis force for reaching movements.

Methods. To distinguish adaptation to a Coriolis force on the carousel, participants were blindfolded and instructed to throw straight ahead of their nose. Initial throws might deviate to the side due to the Coriolis force by itself. Although our apparatus does not measure such an effect directly, we reasoned that, if participants adapt to such a force, it could show up during the posttest as a shift from throwing during the pretest.

Design. Same as previous studies, except for experimental manipulation (see Methods). A total of 16 participants were tested; 8 turned CW and 8 turned CCW.

Results. Averaged over turning direction, the SHIFT in throwing direction decayed from 2.3° for block 1 to about .5° for blocks 3-6, suggesting re-adaptation over time (IV).

II: Design of Studies

Pretest

Throwing while stationary
6 Blocks of 4 throws

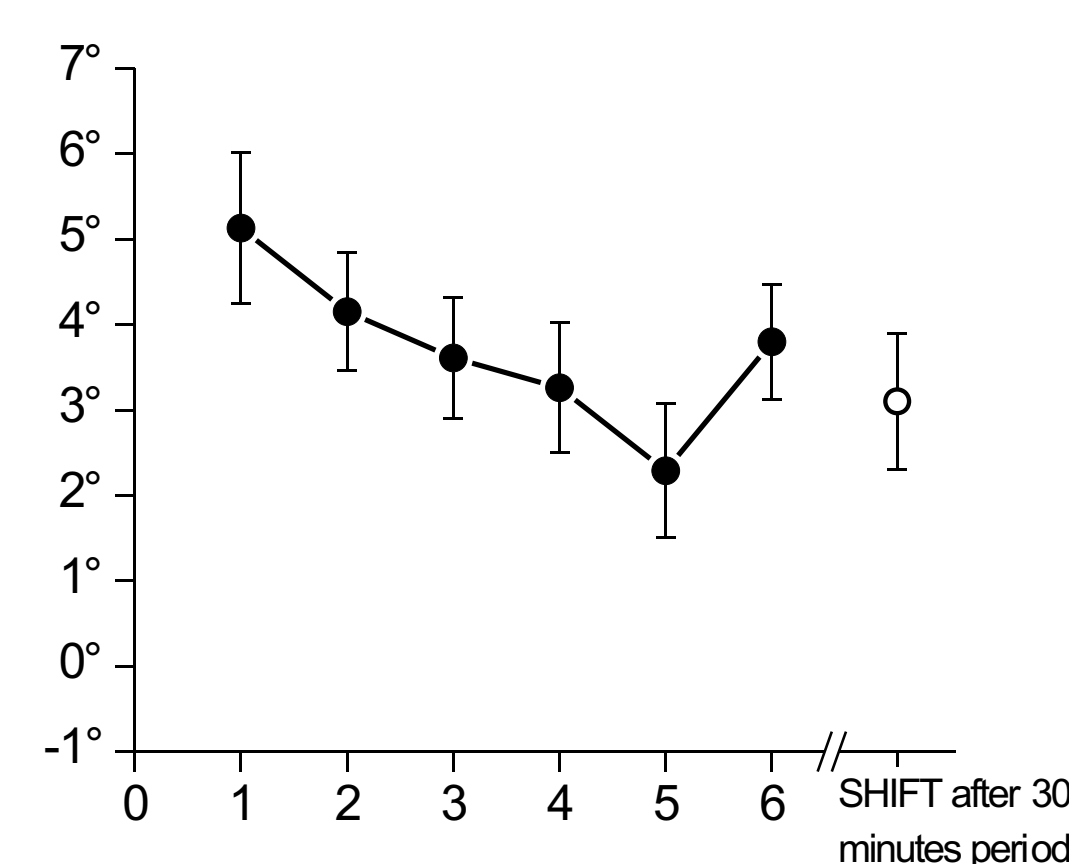
Experimental Manipulation

Throwing on rotating carousel
60 throws

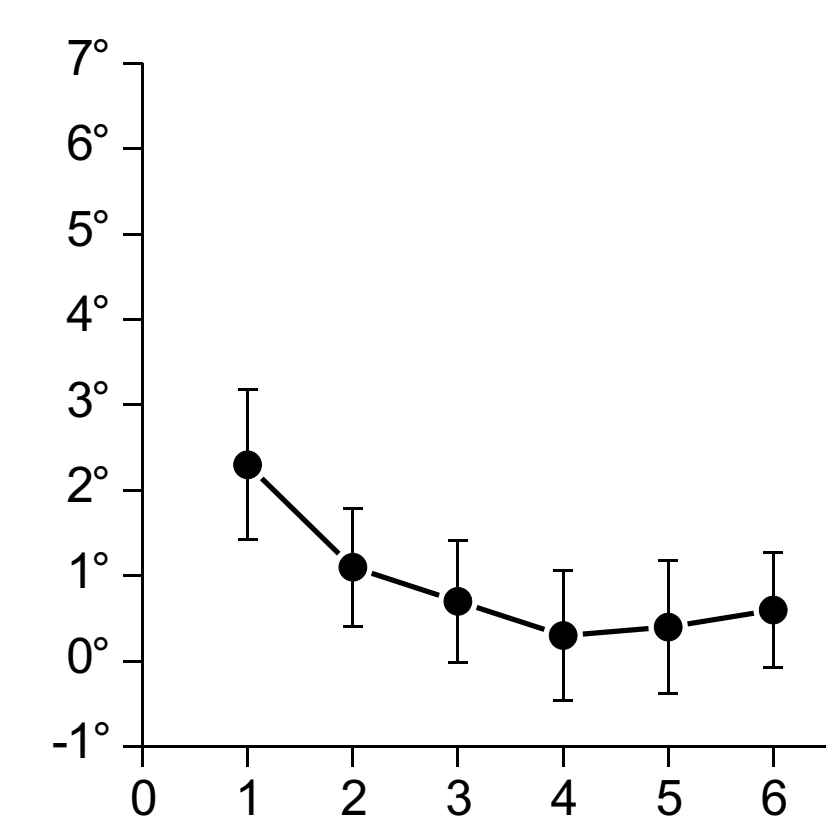
Posttest

Throwing while stationary
6 blocks of 4 throws

III: SHIFT in Throwing

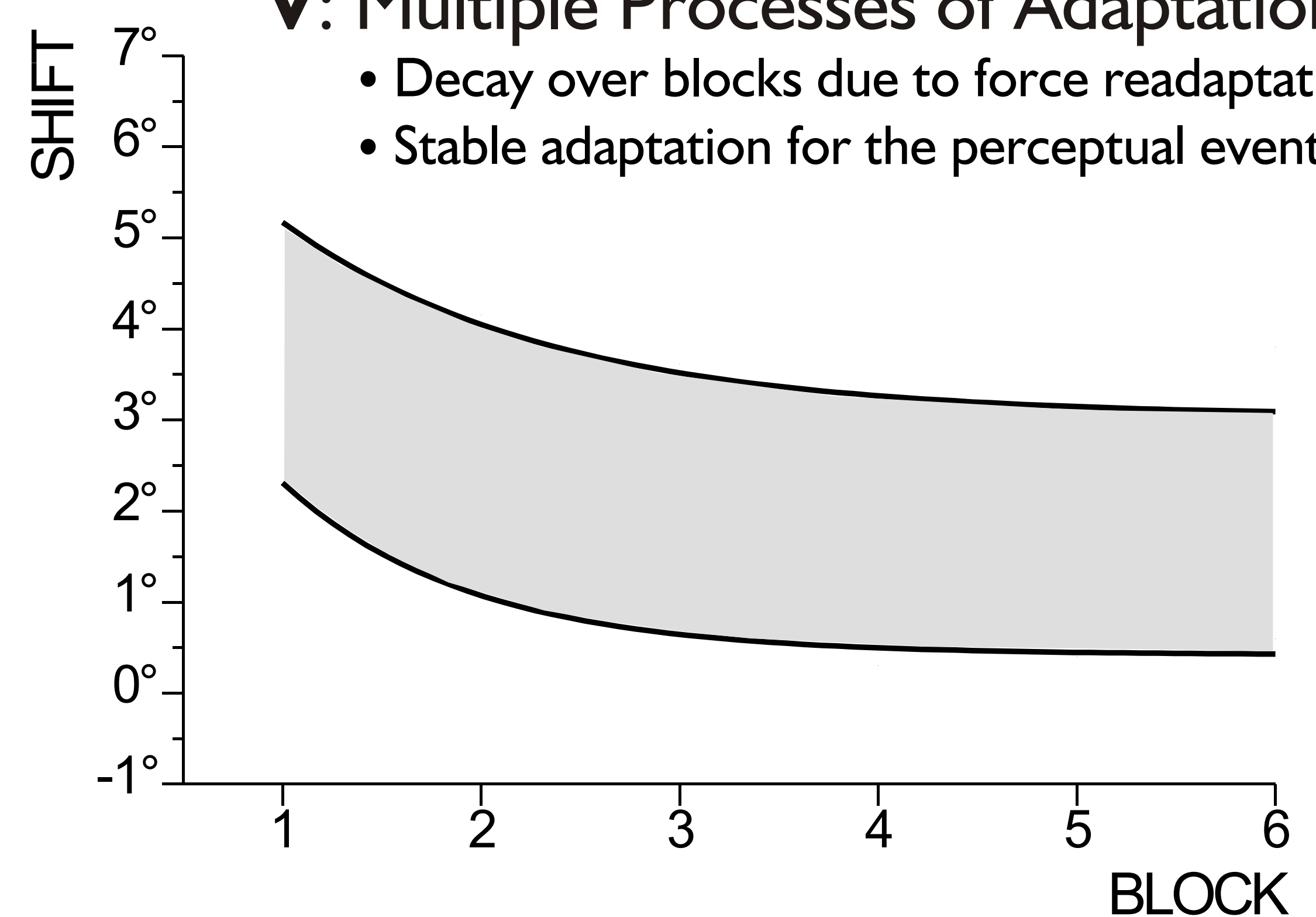


IV: Readaptation to Coriolis Force



V: Multiple Processes of Adaptation

- Decay over blocks due to force readaptation
- Stable adaptation for the perceptual event



Conclusions

Previous studies revealed a decay in SHIFT over test trials. Findings of the present study suggest that such decay might be due to re-adaptation to the Coriolis force. Consequently, throwing on a rotating carousel induces two processes of adaptation (V):

- force field adaptation that decays over test trials, and
- perceptual event adaptation that remains constant (about 3°).

Implications

The evidence for multiple processes of adaptation may imply that movements are organized at multiple levels. To further pursue such an interpretation we suggest:

A. Development of a theoretical framework on movement organization that incorporates the concept of multiple levels. We believe that Bernstein (1996/ORIGINAL DATE); Dexterity and its development) provided the fundamentals for such a framework by defining 4 levels of movement organization; the level of (muscle) Tone, the level of Muscular-Articular Links, the level of Space and the level of Actions.

B. Investigation of multiple levels of movement organization by testing for ranges of transfer of an adaptation across a set of (standardized) variables such as the limbs used, various locations in space as well as the types of action.

REFERENCE

Lackner, J.R. and DiZio, P. (1994) Rapid adaptation to Coriolis force perturbations of arm trajectory. *J. Neurophysiol.* 72, 299-313