Response to Changes in Variability During Movement Under Risk

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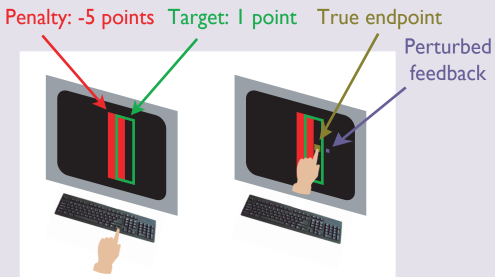
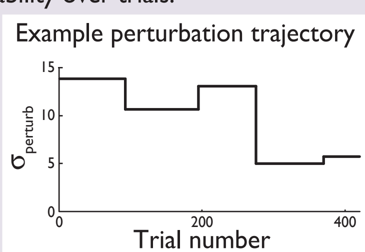
Introduction

- Movements under risk are nearly optimal[1-2].
- In these tasks, humans take into account changes in task-relevant variability[3-4].
- How do they estimate task-relevant variability?
- Researchers typically study reward-based learning of a mean, but not of a variance.

Task: Speeded reach under risk

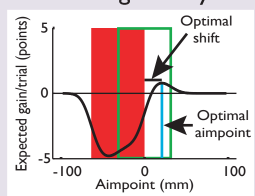


- Horizontal random Gaussian perturbation
- Points awarded based on perturbed endpoint
- $\sigma_{effective} = \left(\sigma^2_{motor} + \sigma^2_{perturb}\right)^{1/2}$
- Random "sample-and-hold" perturbation variability over trials:

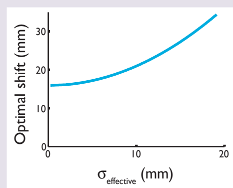


Gain Landscape

The optimal strategy, maximizing expected gain, requires the subject to *shift* the aimpoint from the center of the target away from the penalty region:

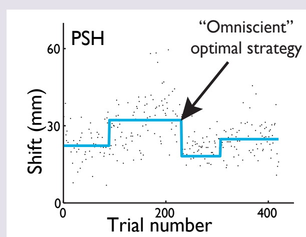


Optimal shift depends on $\sigma_{effective}$



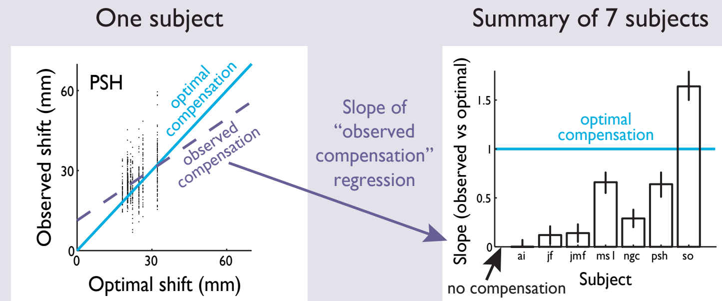
But, subjects have to estimate $\sigma_{perturb}$ dynamically.

Sample data



"Omniscient" optimal strategy based on current trial's value of $\sigma_{perturb}$

Observed vs optimal shift

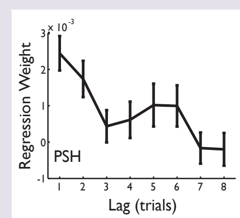


This subject, and all but one of the seven to varying extent, compensates for increased task-relevant variability by shifting the aimpoint further from the penalty.

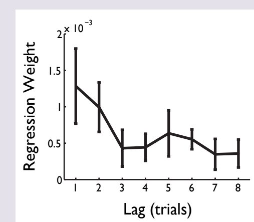
Predicting the current shift

We computed a linear regression of the shift as a function of the squared perturbations of the past eight trials.

One subject



Summary of 7 subjects



Humans dynamically estimate task-relevant variability by computing an exponentially-weighted average of recent squared perturbations.

References: 1. Trommershäuser et al., Spat Vis 2003. 2. Trommershäuser et al., JOSA A 2003. 3. Trommershäuser et al., J Neurosci 2005. 4. Tassinari et al., *SfN Annual Mtg* 2007.

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