Coordinate Frames, Learning and Adaptation, Reaches and Saccades

Michael S. Landy
with: Todd E. Hudson & John-Ross Rizzo

Department of Psychology and
Center for Neural Science
NYU

Why am I here?

Journal of Vision (2015) 15(16):8, 1–12 1

Near-optimal integration of orientation information across saccades

Elad Ganmor Center for Neural Science, New York University, New York, NY, USA

Michael S. Landy Center for Neural Science, New York University, New York, NY, USA; Department of Psychology, New York University, New York, NY, USA

Eero P. Simoncelli Center for Neural Science, New York University, New York, NY, USA; Courant Institute of Mathematical Sciences, New York University, New York, NY, USA; Department of Psychology, New York University, New York, NY, USA; Howard Hughes Medical Institute, New York University, New York, NY, USA

Why am I here?

Journal of Vision (2015) 15(16):1, 1–18 1

Trans-saccadic integration of peripheral and foveal feature information is close to optimal

Christian Wolf Abteilung Allgemeine Psychologie, Justus-Liebig-Universität Gießen, Gießen, Germany

Alexander C. Schütz Abteilung Allgemeine Psychologie, Justus-Liebig-Universität Gießen, Gießen, Germany; Allgemeine und Biologische Psychologie, Philipps-Universität Marburg, Marburg, Germany

Why am I here?

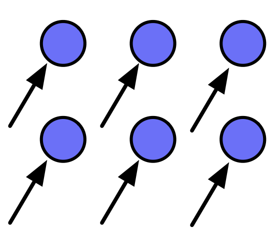
Journal of Vision (2013) 13(3):0, 1–20 http://www.journalofvision.org/content/13/3/0 1

Choice of saccade endpoint under risk

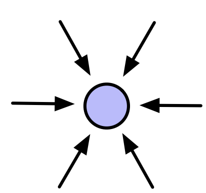
John F. Ackermann Department of Psychology, New York University, New York, NY, USA

Michael S. Landy Department of Psychology, New York University, New York, NY, USA; Department of Neural Science, New York University, New York, NY, USA

Reach Coding

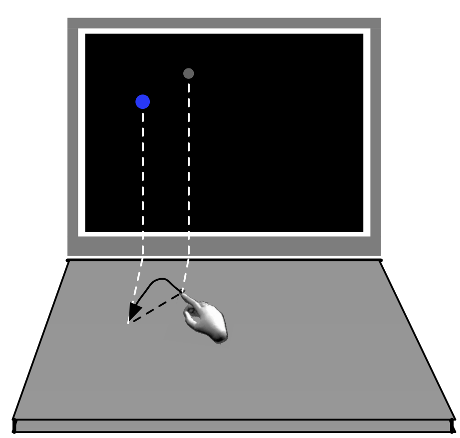


Ghez et al., 1997, 2007
Ghilardi et al., 1995
Rossetti et al., 1995
Scheidt & Ghez, 2007
Vindras et al., 2005



Shadmehr et al., 1993
Thaler & Todd, 2009
van den Dobbelsteen et al., 2001

Reach Coding



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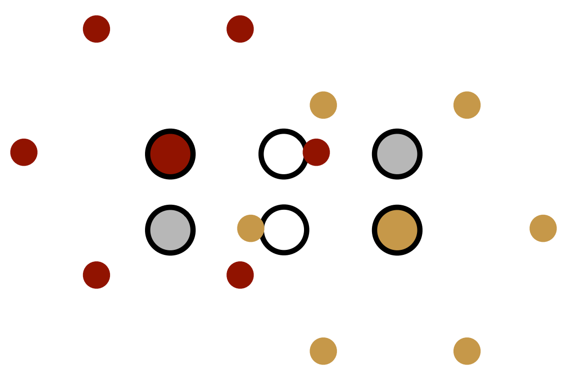
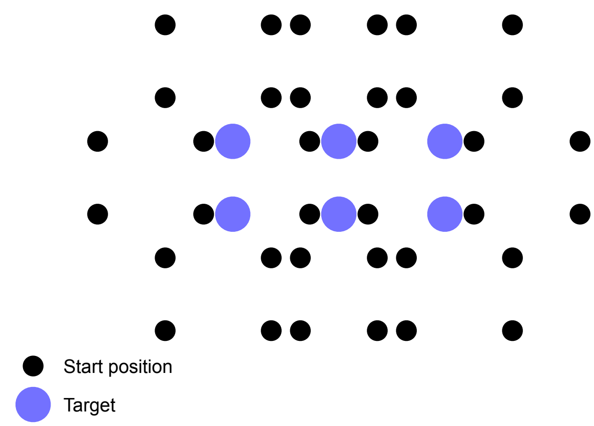
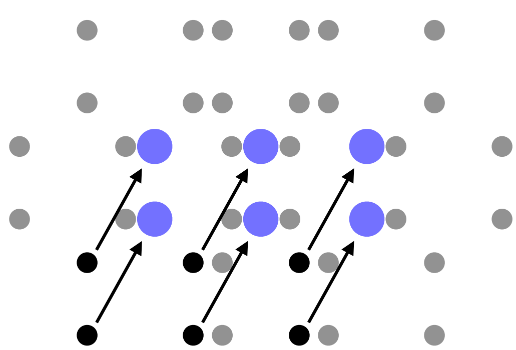


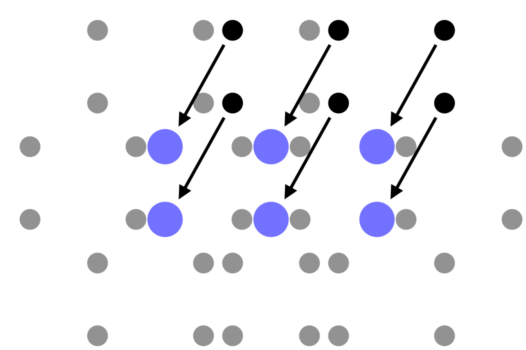
Reach Coding



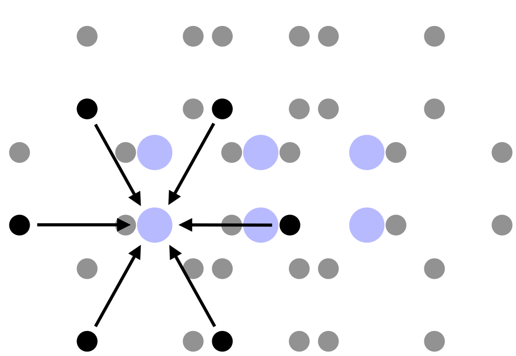
Reach Coding – Vector Grouped



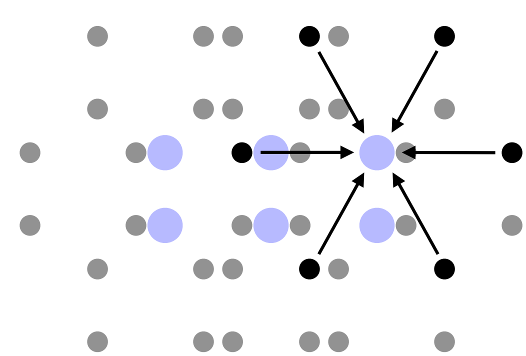
Reach Coding – Vector Grouped



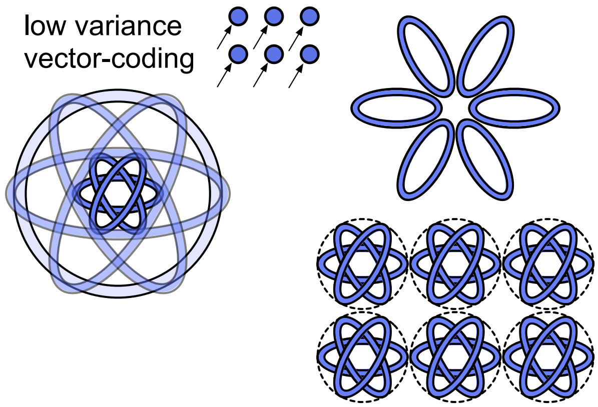
Reach Coding – Target Grouped



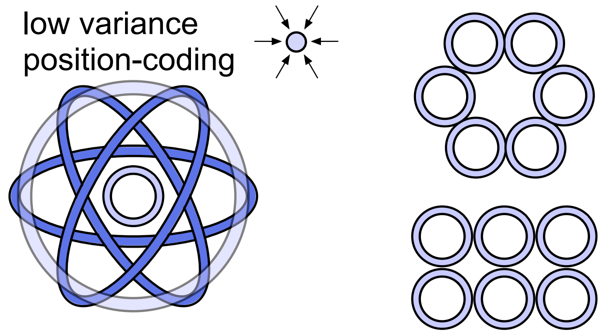
Reach Coding – Target Grouped



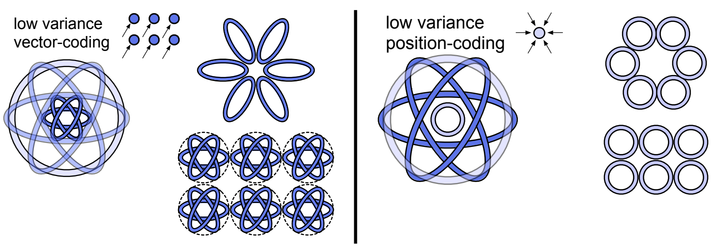
Reach Coding – Predictions



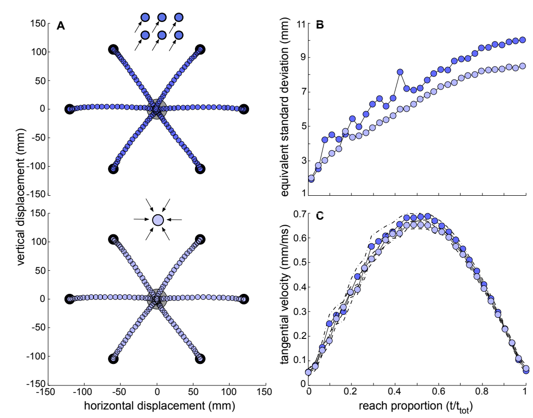
Reach Coding – Predictions



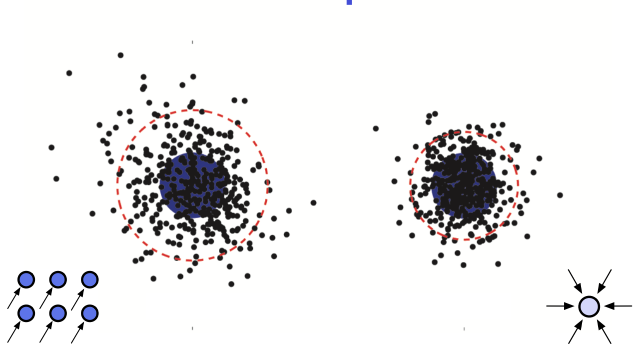
Reach Coding – Predictions



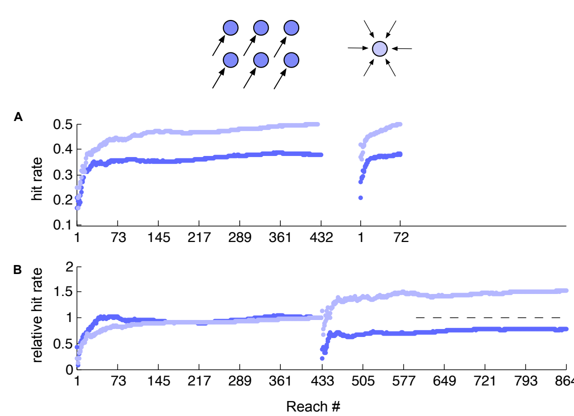
Reach Coding – No Effect of Grouping on Mean Trajectory



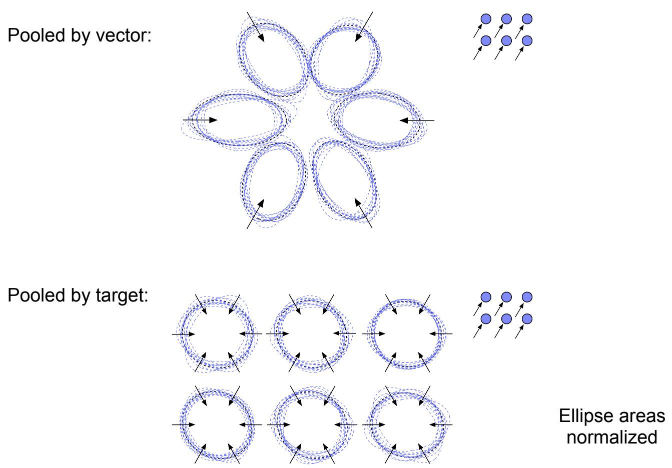
Reach Coding – Variability is Larger for Vector-Grouped Reaches



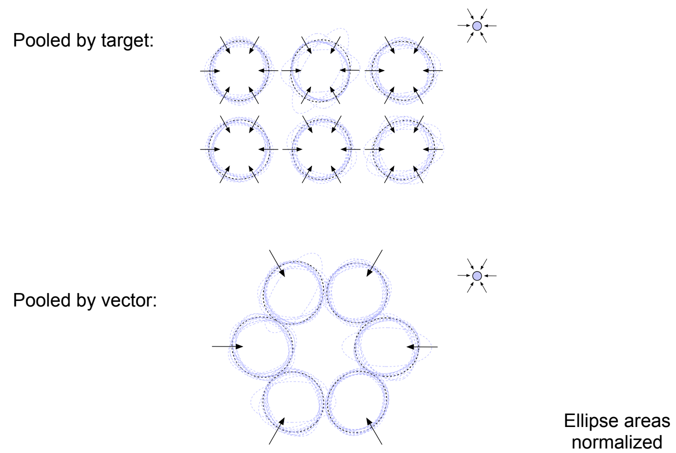
Effect of Grouping on Hit Rate



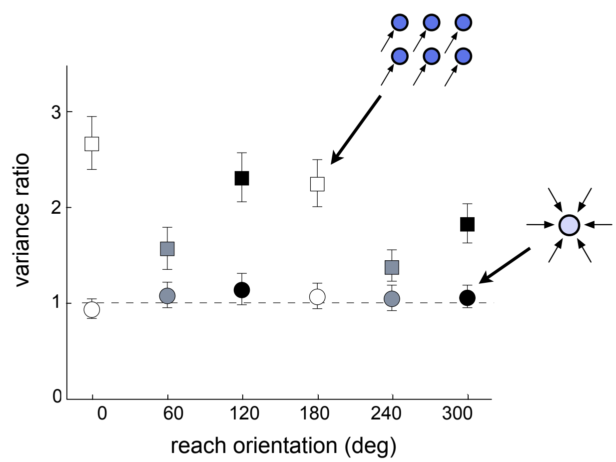
Variability: Vector-Grouped Reaches



Variability: Target-Grouped Reaches



Variance Ratio: Along/Across Reach



Summary

We have provided evidence for two movement-planning systems: vector- and target-based.

Each system improves when practice is grouped in the manner appropriate for that system (i.e., by vector or by target).

The vector-based system produces anisotropic variability, larger along the reach direction; the target-based system produces isotropic and, at asymptote, lower variability (and hence higher hit rate).

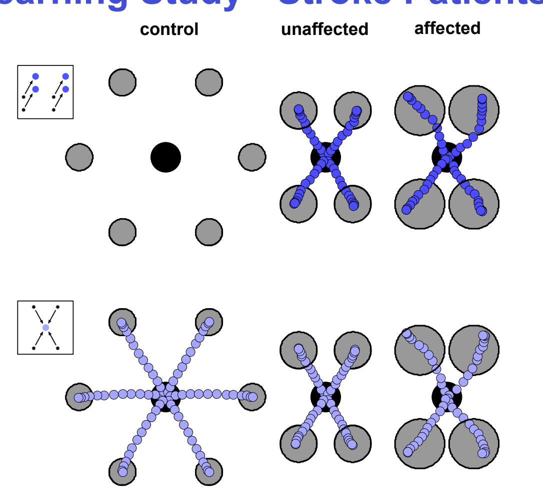
Hudson & Landy, *J Neurophysiol*, 2012

Hypothesis

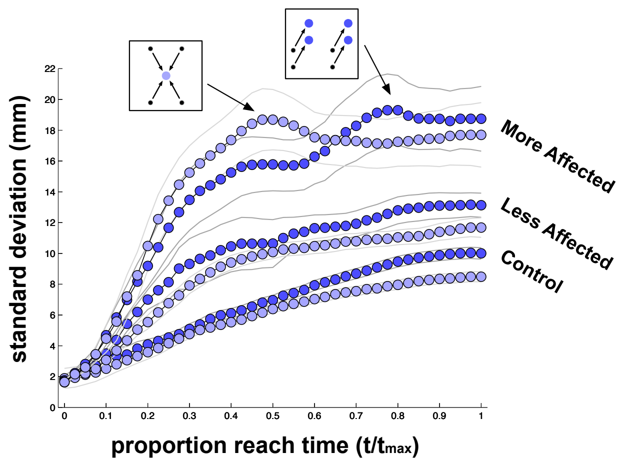
There is a large amount of evidence that multiple sensory cues are combined optimally in sensory estimation.

Perhaps multiple movement plans (i.e., vector- and target-based) are also combined optimally, taking into account their current respective variances, to form the movement command.

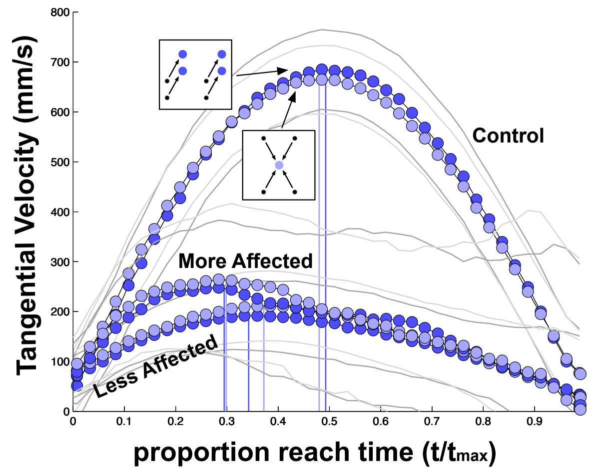
Learning Study - Stroke Patients



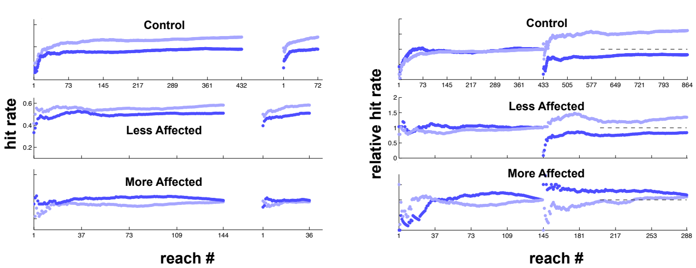
Learning Study - Stroke Patients



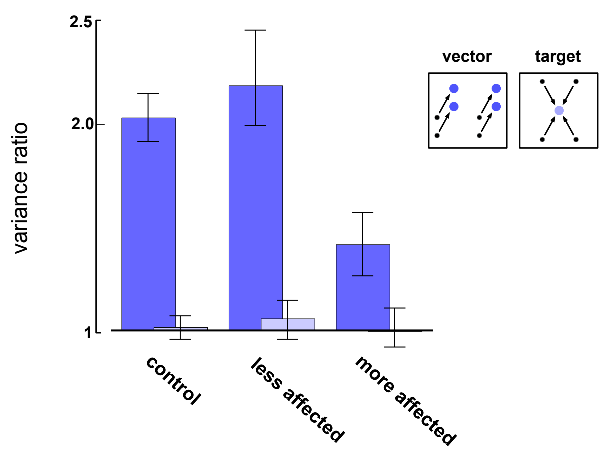
Learning Study - Stroke Patients



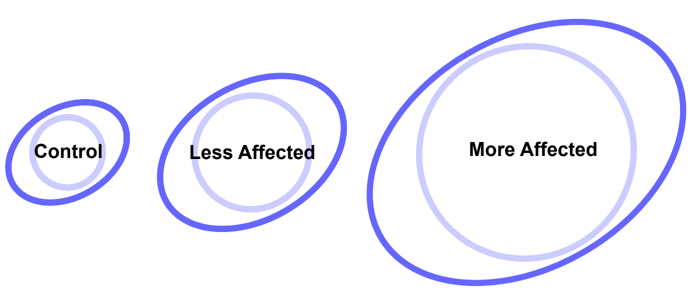
Learning Study - Stroke Patients



Learning Study - Stroke Patients



Learning Study - Stroke Patients



Summary

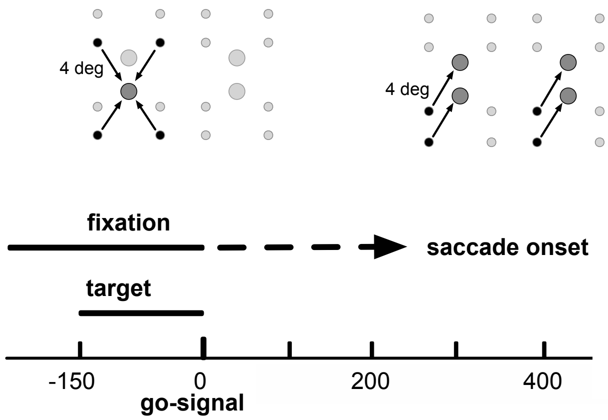
Just as for controls, patients with stroke show circular error ellipses for target-grouped reaches and errors elongated along the reach direction for vector-grouped reaches.

Patients with stroke show increased error variance in both the more and less affected arms.

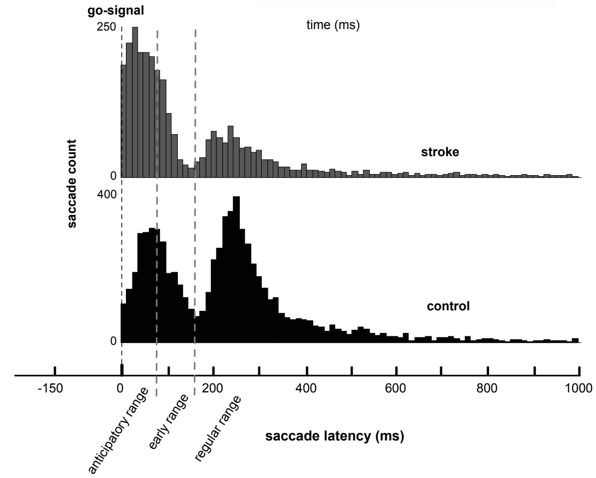
However, the more affected arm showed less elongated error ellipses for vector-grouped reaches compared to the less affected arm, particularly in individuals with right-hemispheric stroke.

Rizzo et al., *Physiological Reports,* 2015

Learning Design: Saccades



Learning Design: Saccades



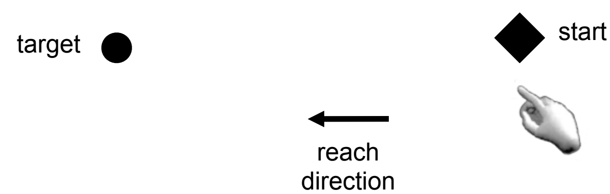
Summary

In the learning design, we saw no evidence of circular covariance for target-grouped saccades, i.e., only a vector-based saccadic planning system was found.

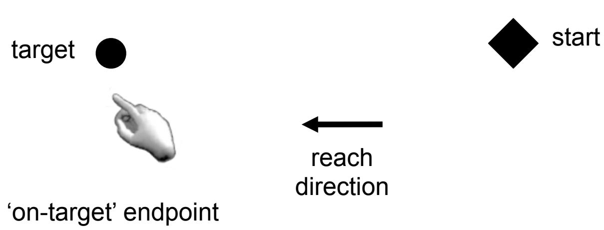
Patients with stroke show increased numbers of early saccades, suggesting a deficit in inhibitory control. Their saccades were also more hypometric.

Rizzo et al., under review

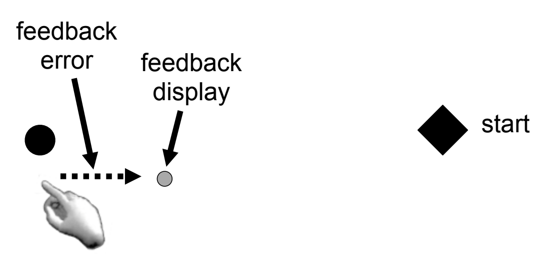
Reach Adaptation



Reach Adaptation

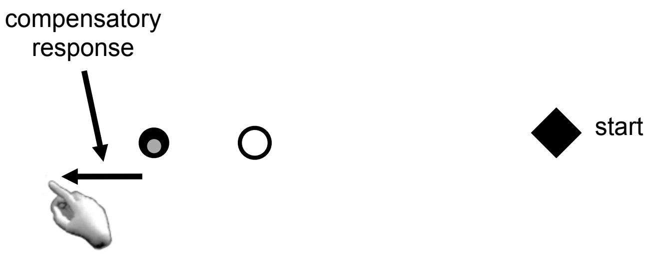


Reach Adaptation



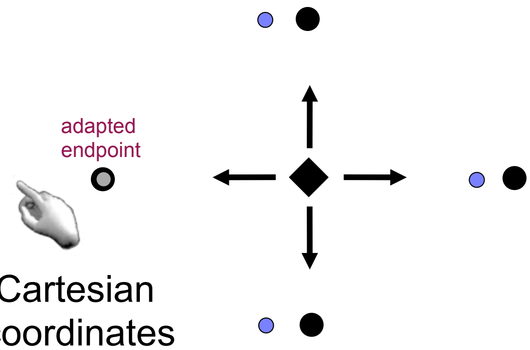
Shift reach feedback, leading in this case to evidence for too-low reach gain.

Reach Adaptation



Compensatory response: reach further so that feedback is on-target.

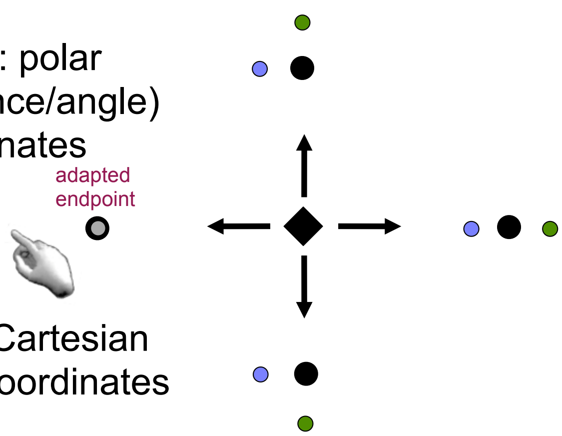
Reach Adaptation - Coordinate Frame



Blue: Cartesian (x/y) coordinates

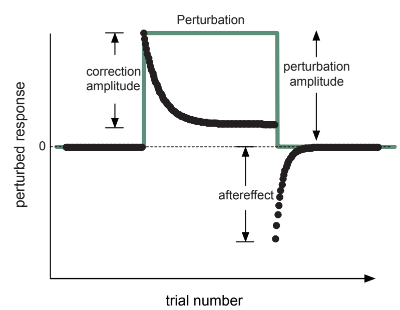
Reach Adaptation - Coordinate Frame

Green: polar (distance/angle) coordinates



Blue: Cartesian (x/y) coordinates

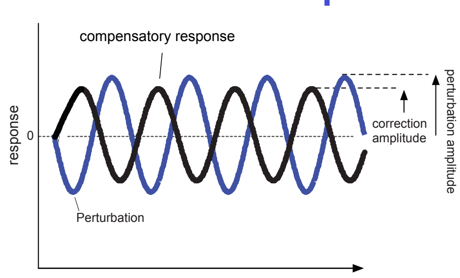
Measuring Adaptation: Step-function Adapter



Problems

- perturbation needs to be large (and noticeable)
- dynamics fast and thus hard to measure

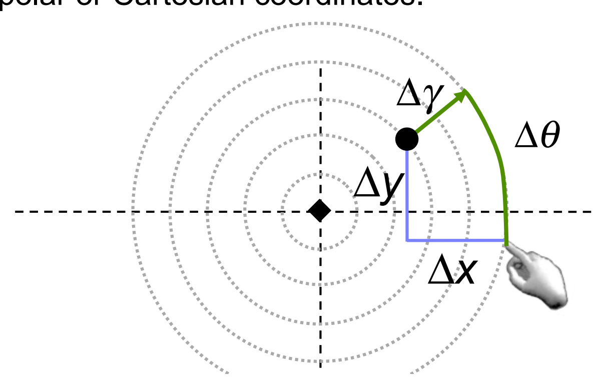
Measuring Adaptation: Sinewave Adapter



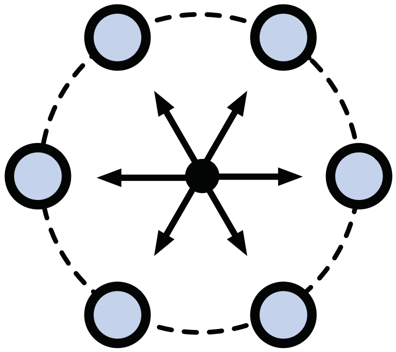
- substantially more sensitive than step-function adaptation
- perturbations can be so small as to remain undetected
- every trial contributes to estimates of gain and phase lag

Harwood & Wallman, SFN, 2004; Hudson & Landy, *J Neurosci Meths, 2012*

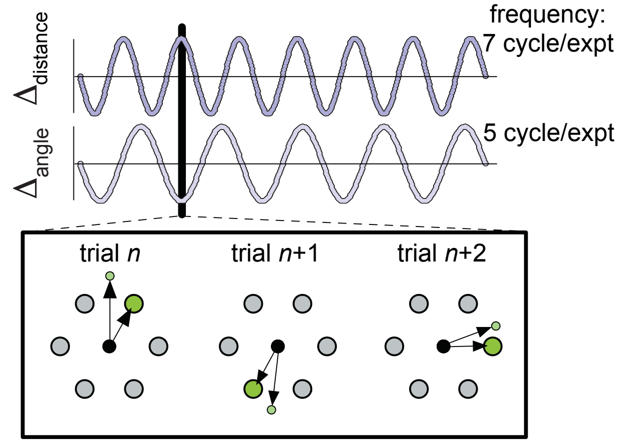
We would like to know whether reaches and reach errors are encoded/represented using polar or Cartesian coordinates.



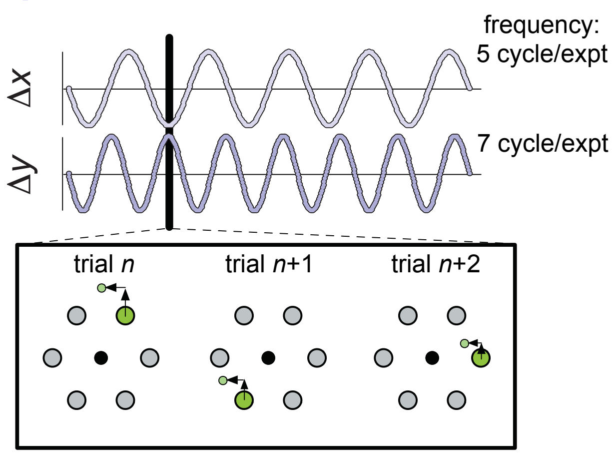
Expt. 1: Six center-out reaches



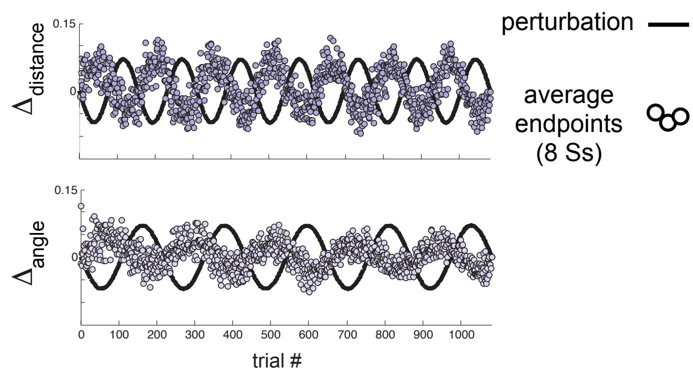
Adaptation: Polar Perturbation



Adaptation: Cartesian Perturbation

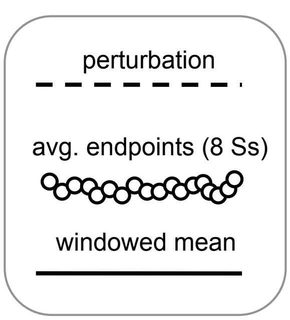


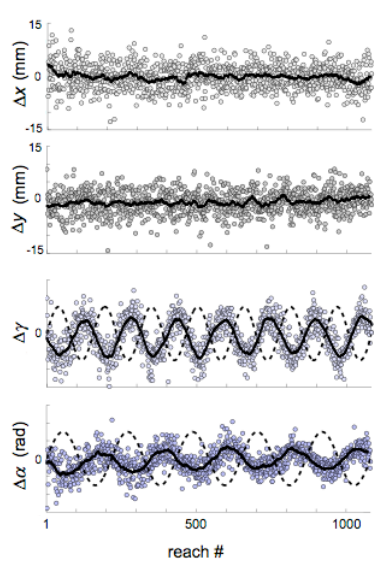
Expt. 1: "Raw" Results
Polar Perturbation



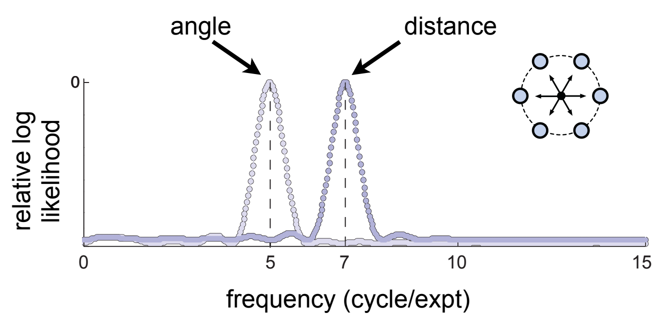
Experimental Results

polar ($\gamma\alpha$)-perturbed endpoints

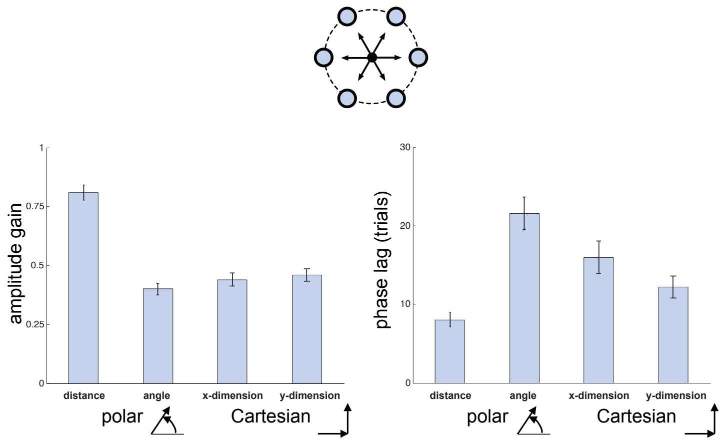




Expt. 1: No Crosstalk



Expt. 1: Gain and Lag



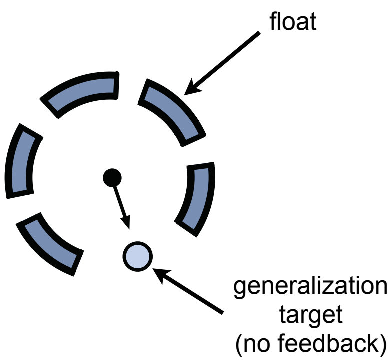
Problem: What if adaptation were target-specific?

This is equivalent to reaching to a single target, in the sense that there is a separate mapping for each target.

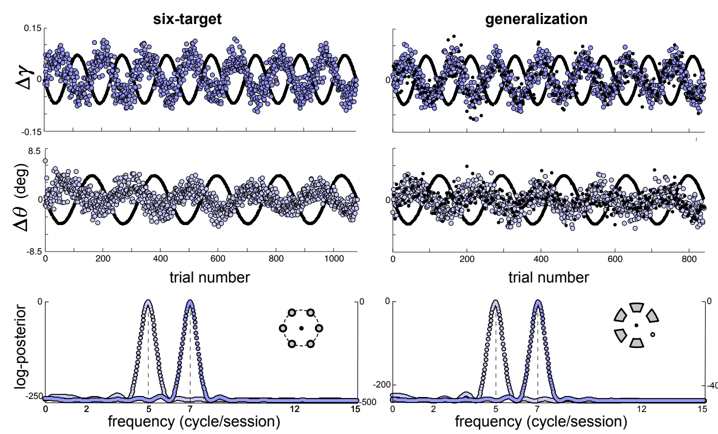
This could show similar results using *either* coordinate system.

Thus, we would not be able to distinguish between polar and Cartesian representations.

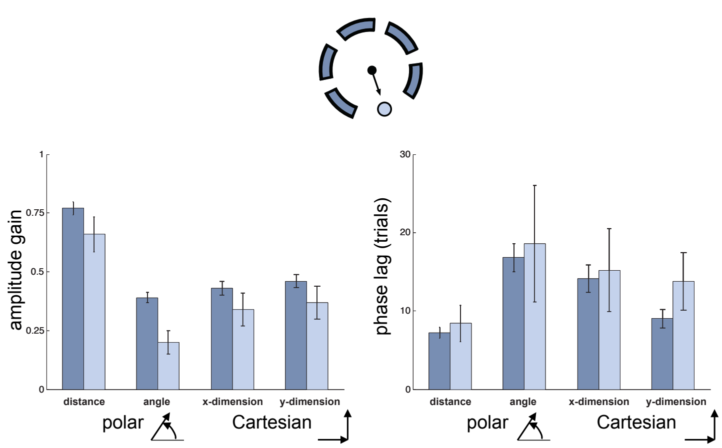
Expt. 2: Generalization Target and “Float”



Expt. 1 and 2: Raw Results



Expt. 2: Gain and Lag

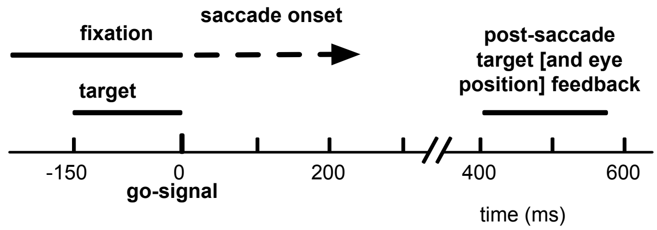


Summary

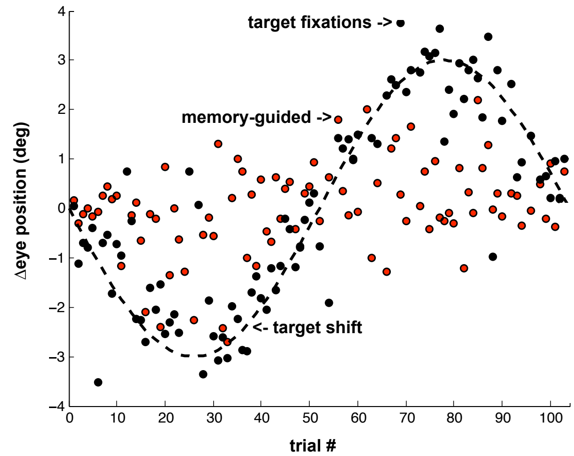
- A new, highly sensitive technique for inducing adaptation and estimating amount and dynamics of the adaptive response
- Along with the vector- and target-coded systems for reach planning, there are polar and Cartesian systems for adaptation
- Adaptation is independent in x and y, and in distance and angle
- Visuo-motor adaptation is not strictly local

Hudson & Landy, *Vision Research*, 2016

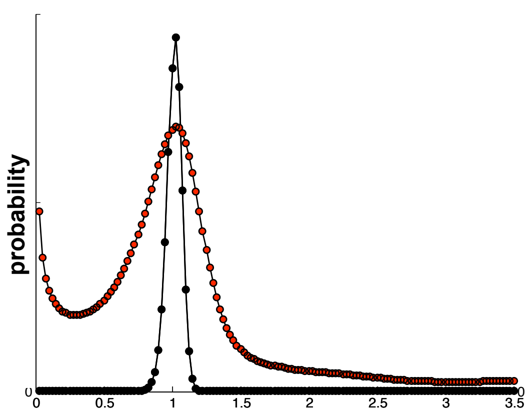
Saccade Adaptation



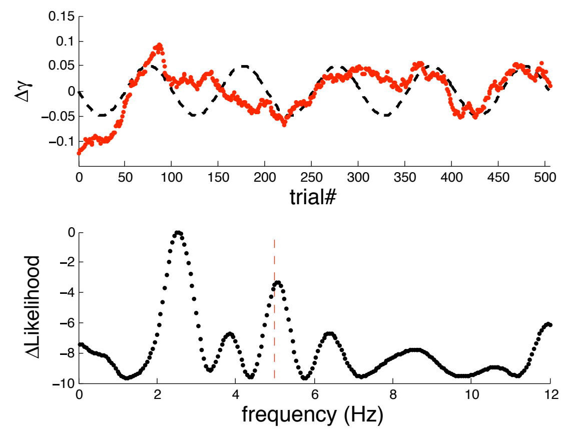
Saccade Adaptation



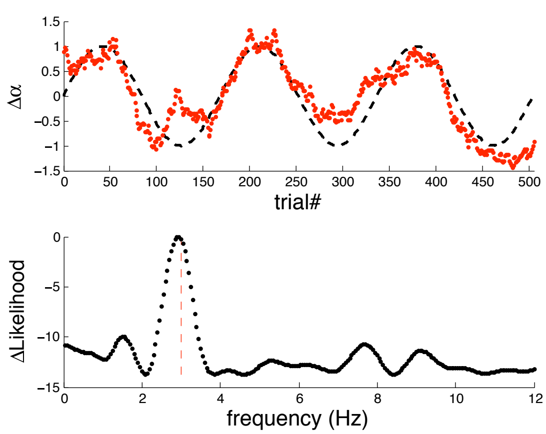
Saccade Adaptation



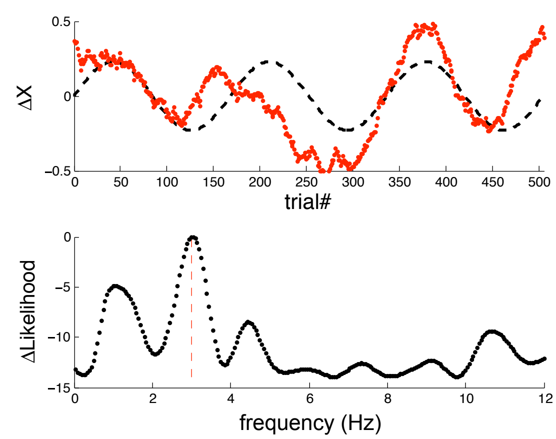
Saccade Adaptation



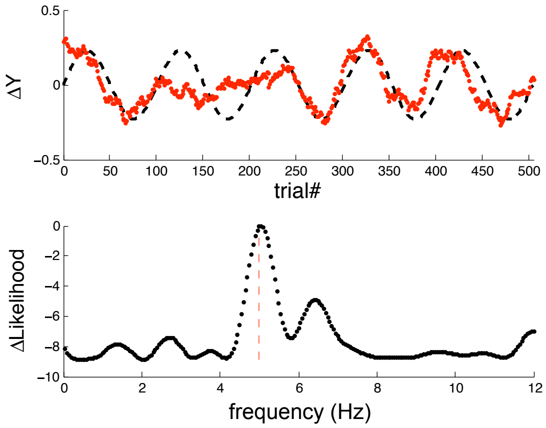
Saccade Adaptation



Saccade Adaptation



Saccade Adaptation



Saccade Adaptation

J Neurophysiol 116: 336–350, 2016.
First published April 20, 2016; doi:10.1152/jn.00206.2016.

Saccadic adaptation to a systematically varying disturbance

Carlos R. Cassanello, Sven Ohl, and Martin Rolfs
Department of Psychology and Bernstein Center for Computational Neuroscience, Humboldt Universität zu Berlin, Berlin, Germany

Submitted 9 March 2016; accepted in final form 18 April 2016

Summary

- In better hands, the sinewave-adaptation technique can be used to study saccade adaptation
- The jury is perhaps still out as to the extent to which saccadic adaptation is local vs. global, and whether there is a Cartesian as well as a polar coordinate system for planning saccades

Overall Summary

Along with the vector- and target-coded systems for reach planning, there appear to be adaptation systems, separate for each, both put into play in determining motor output, at least for reaches.

While we recognize the need to determine the regions (global, local, how local?) over which errors are pooled (viz. Krakauer and colleagues), it seems clear that adaptation is not strictly local.