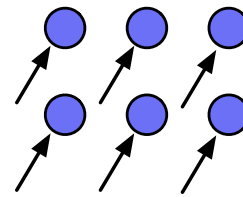# Multiple Coordinate Frames for Reaches Revealed Through Adaptation
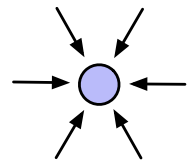
Michael S. Landy
Todd E. Hudson

Department of Psychology and
Center for Neural Science
NYU

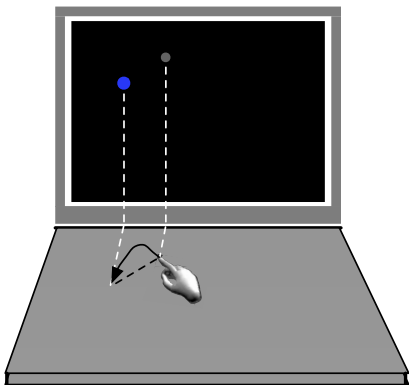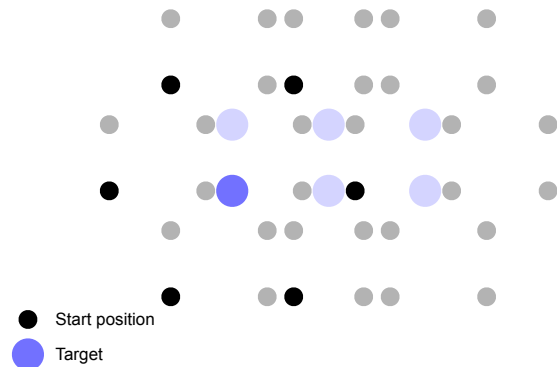# Reach Coding

Vector-based   Target-based
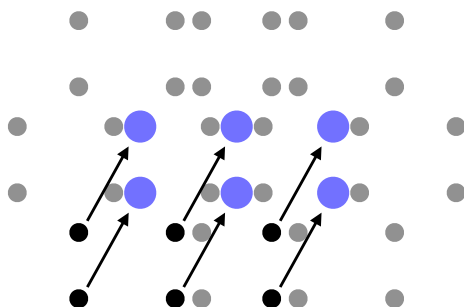
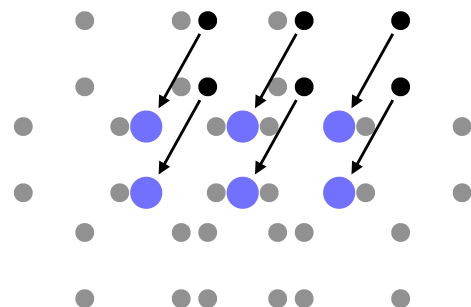Landy, M. S. & Hudson, T. E. (2011). *JOV 11(11):970.*

Reach Coding
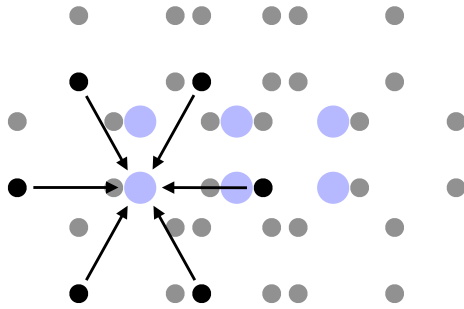
● Start position
● Target

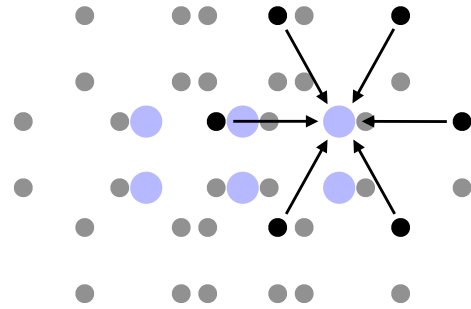# Reach Coding – Vector Grouped

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Reach Coding – Vector Grouped

Reach Coding – Target Grouped

Reach Coding – Target Grouped

Reach Coding

vector-grouped   target-grouped
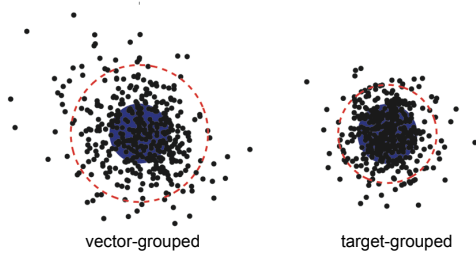
For vector-grouped reaches, variability is
- larger
- extended along the reach (not shown)

Reach Adaptation

target ●   ◆ start

reach
direction

Reach Adaptation

target ●   ◆ start

reach
direction

'on-target' endpoint

Reach Adaptation

feedback
error   feedback
display

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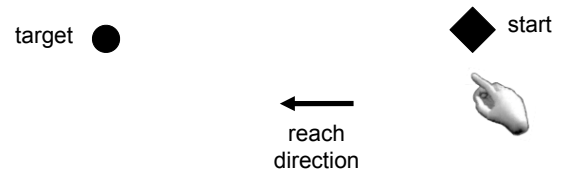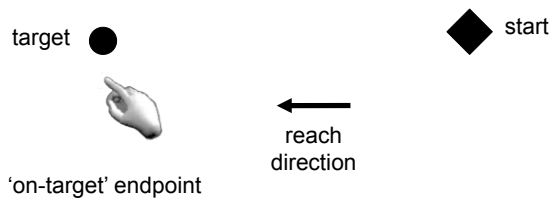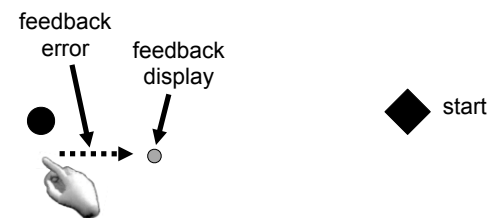
Shift reach feedback, leading in this case to evidence for
too-low reach gain.

Reach Adaptation

compensatory response

start

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

Reach Adaptation - Coordinate Frame

adapted endpoint

Blue: Cartesian (x/y) coordinates

Reach Adaptation - Coordinate Frame

Green: polar (distance/angle) coordinates

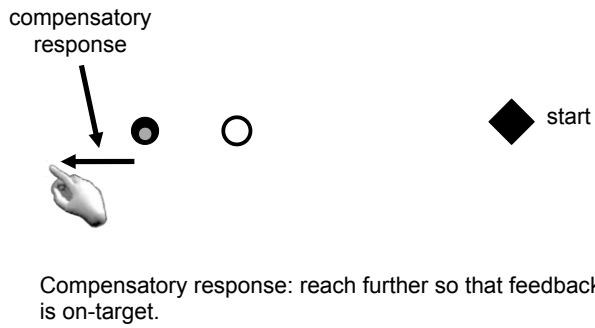adapted endpoint

Blue: Cartesian (x/y) coordinates
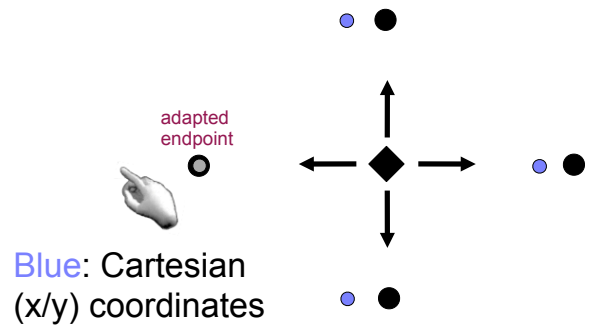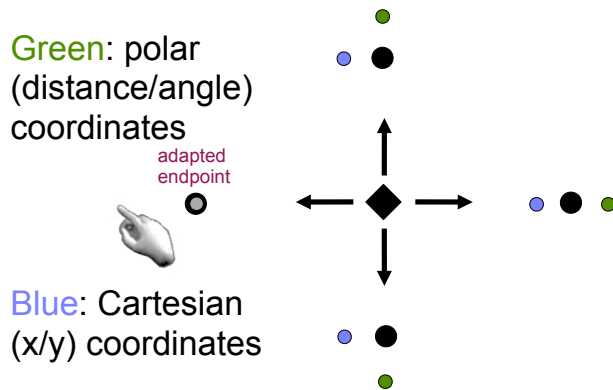
Measuring Adaptation: Step-function Adapter

Perturbation

correction amplitude

perturbation amplitude

perturbed response

0

aftereffect

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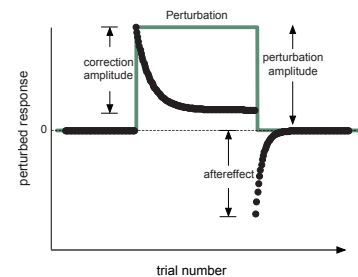
Problems
- perturbation needs to be large (and noticeable)
- dynamics fast and thus hard to measure

Measuring Adaptation: Sinewave Adapter

compensatory response

response

0

perturbation amplitude

correction amplitude

Perturbation
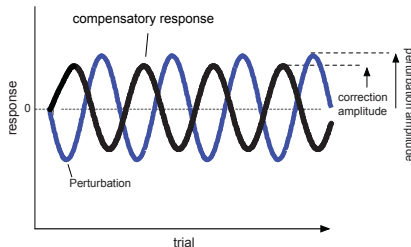
trial

- 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

Hudson, T. E. & Landy, M. S. (in press). *J Neurosci Meths*

Expt. 1: Six center-out reaches

Adaptation: Polar Perturbation

frequency:
7 cycle/expt

$\Delta_{distance}$

5 cycle/expt

Δ_{angle}

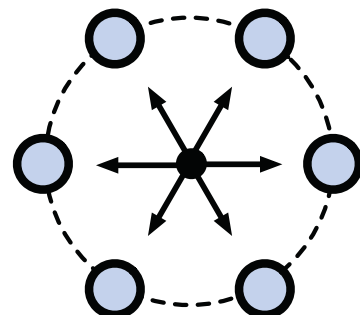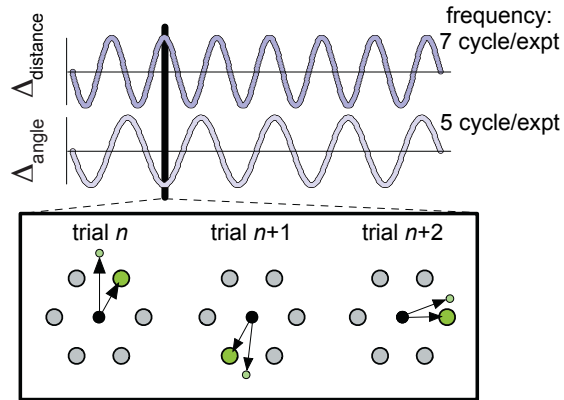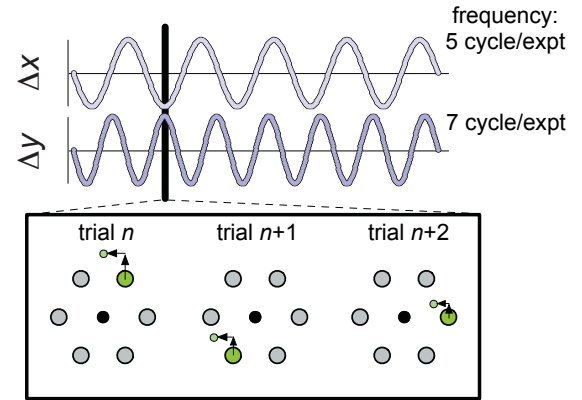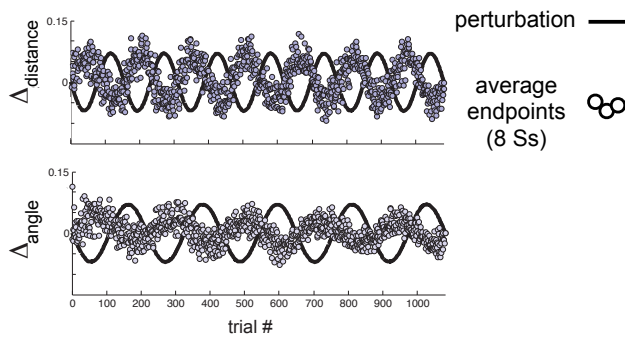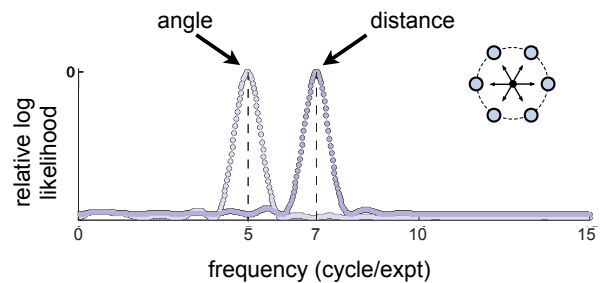trial n trial $n+1$ trial $n+2$

Adaptation: Cartesian Perturbation

frequency:
5 cycle/expt

Δx

7 cycle/expt

Δy

trial n trial $n+1$ trial $n+2$

Expt. 1: "Raw" Results
Polar Perturbation

0.15

$\Delta_{distance}$

0

perturbation ___

average
endpoints
(8 Ss)

0.15

Δ_{angle}

0   100   200   300   400   500   600   700   800   900 1000

trial #

Expt. 1: No Crosstalk

angle   distance

0

relative log
likelihood

0   5   7   10   15

frequency (cycle/expt)

Expt. 1: Gain and Lag

1

0.75

amplitude gain

0.5

0.25

0

distance   angle   x-dimension   y-dimension

polar   Cartesian

30

phase lag (trials)

20

10

0

distance   angle   x-dimension   y-dimension
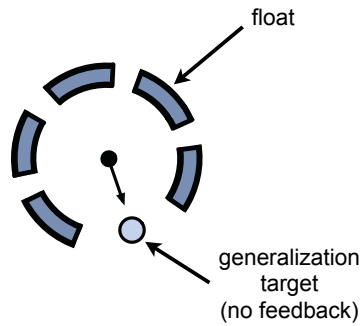
polar   Cartesian
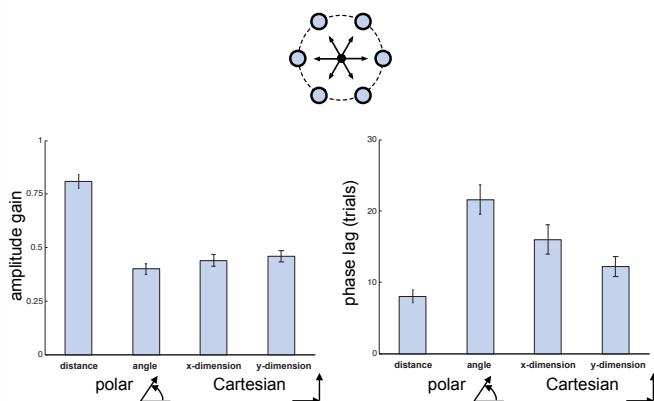
Problem: What if adaptation were target-specific?

This is equivalent to reaching to a single target, in the sense that there is a separate mapping for each target.
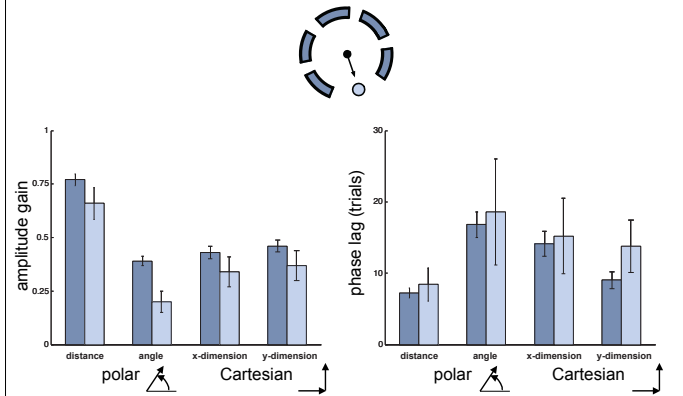
This could show similar results using *either* coordinate system.

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

Expt. 2: Generalization Target and "Float"

float

generalization
target
(no feedback)

Expt. 2: Gain and Lag

amplitude gain

1
0.75
0.5
0.25
0

distance   angle   x-dimension   y-dimension
polar   Cartesian

phase lag (trials)

30
20
10
0

distance   angle   x-dimension   y-dimension
polar   Cartesian

Conclusions

- 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