RELATIVE WEIGHTS OF STATIC AND DYNAMIC VISUAL CUES IN THE PERCEPTION OF BODY ROLL

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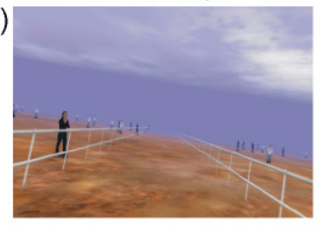
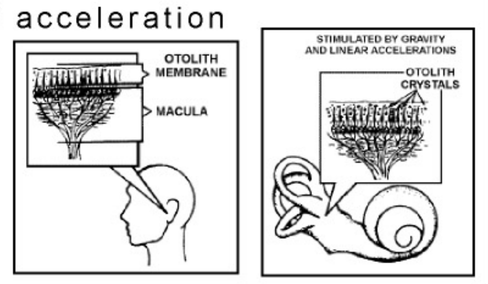
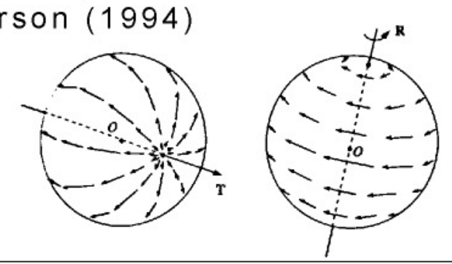
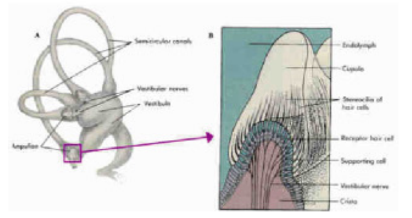
INTRODUCTION

Static cues to body orientation provide information about the direction of gravity in body coordinates

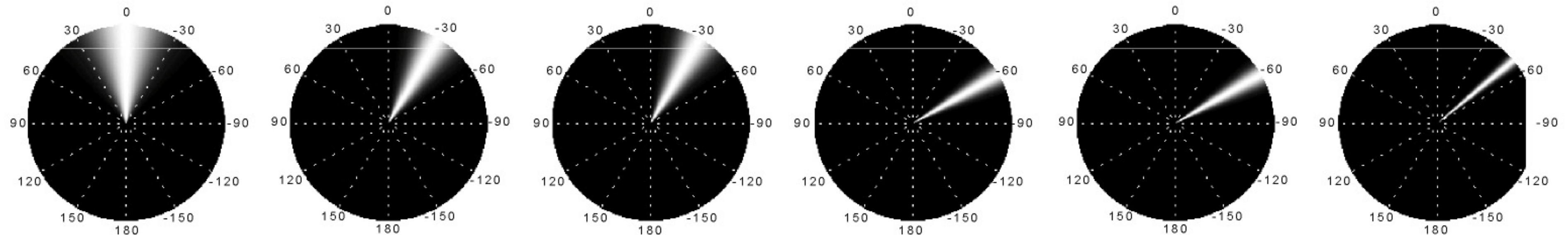
Dynamic cues provide information about changes in body orientation (self-rotation); must be integrated over time to yield an orientation estimate

	Visual	Vestibular
Static	Objects of known orientation "Polarized" objects (Howard, 1982) Horizon (Gibson, 1950) Frame (Witkin & Asch, 1948) 	Otoliths Ambiguous b/c of acceleration A-effect (Mittelstaedt, 1983) E-effect 
Dynamic	Optic flow from self-rotation Dichgans et al. (1972) Howard & Childerson (1994) 	Semi-circular canals Noisy b/c of integration Disambiguating (Angelaki et al, 2004; Merfeld et al, 1999) 

Bayesian combination rule: $p(O)p(S|O) \propto p(O|S)$

Assuming independent noise, this can be expressed:

Prior	Vestibular Cues		Visual Cues		Posterior
$p(O)$	$p(S_o\|O)$	$p(S_c\|O)$	$p(S_s\|O)$	$p(S_d\|O)$ $\propto$	$p(O\|S)$



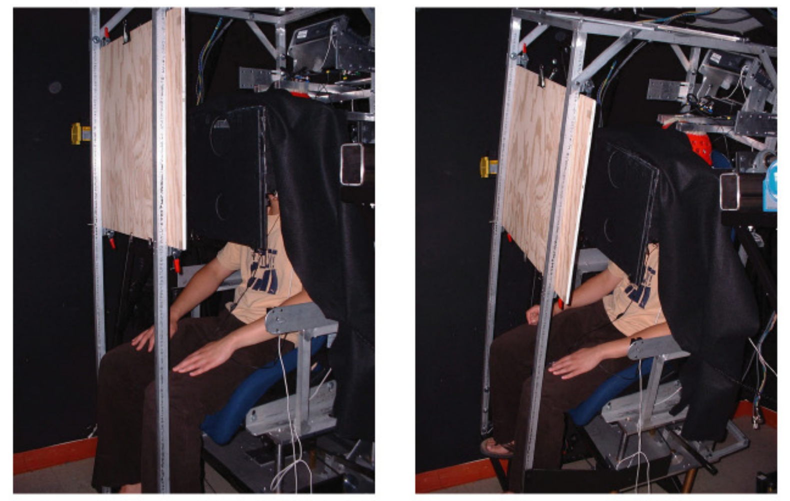
Combined estimate is based on the posterior:

Most influenced by least variable likelihood or prior

More precise than any of the likelihoods or priors

METHODS

Equipment:



Rotating chair +/-20 deg range in roll, pitch & yaw

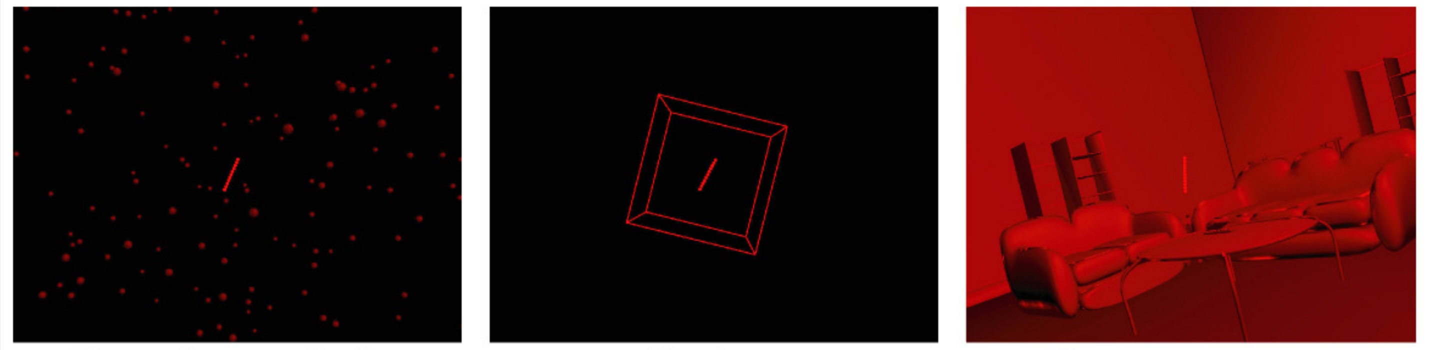
Procedure:

10 deg start position
4 sec rotation to 12, 14 or 16 deg
Rod-setting task
4 sec rotation back to 10 deg
Alternate, 5 left, 5 right

Conditions:

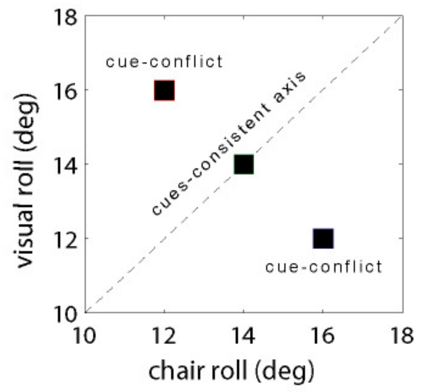
Non-visual: only rod visible
Static cube: stationary cube
Static room: stationary room
Dynamic dots: rotating dots
Dynamic room: rotating room

Visual Scenes:



Random dots · Cube · Room scene

Cue-conflict design:



DISCUSSION

- Static visual information was weighted more highly than dynamic.
  - Dynamic information is not a reliable cue to orientation.
- The static scene was weighted more highly than the static cube.
  - Real-world scenes are more reliable cues to orientation.
- Dynamic visual information caused some subjects to weight non-visual information more highly, perhaps because of conflict detection.
- Future work: 1) Measure variability of likelihoods and prior.
  2) Measure conflict detection and its effect on weights.

References:

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Dichgans J, Held R, Young LR, Brandt T (1972) Moving visual scenes influence the apparent direction of gravity. Science 178:1217-9

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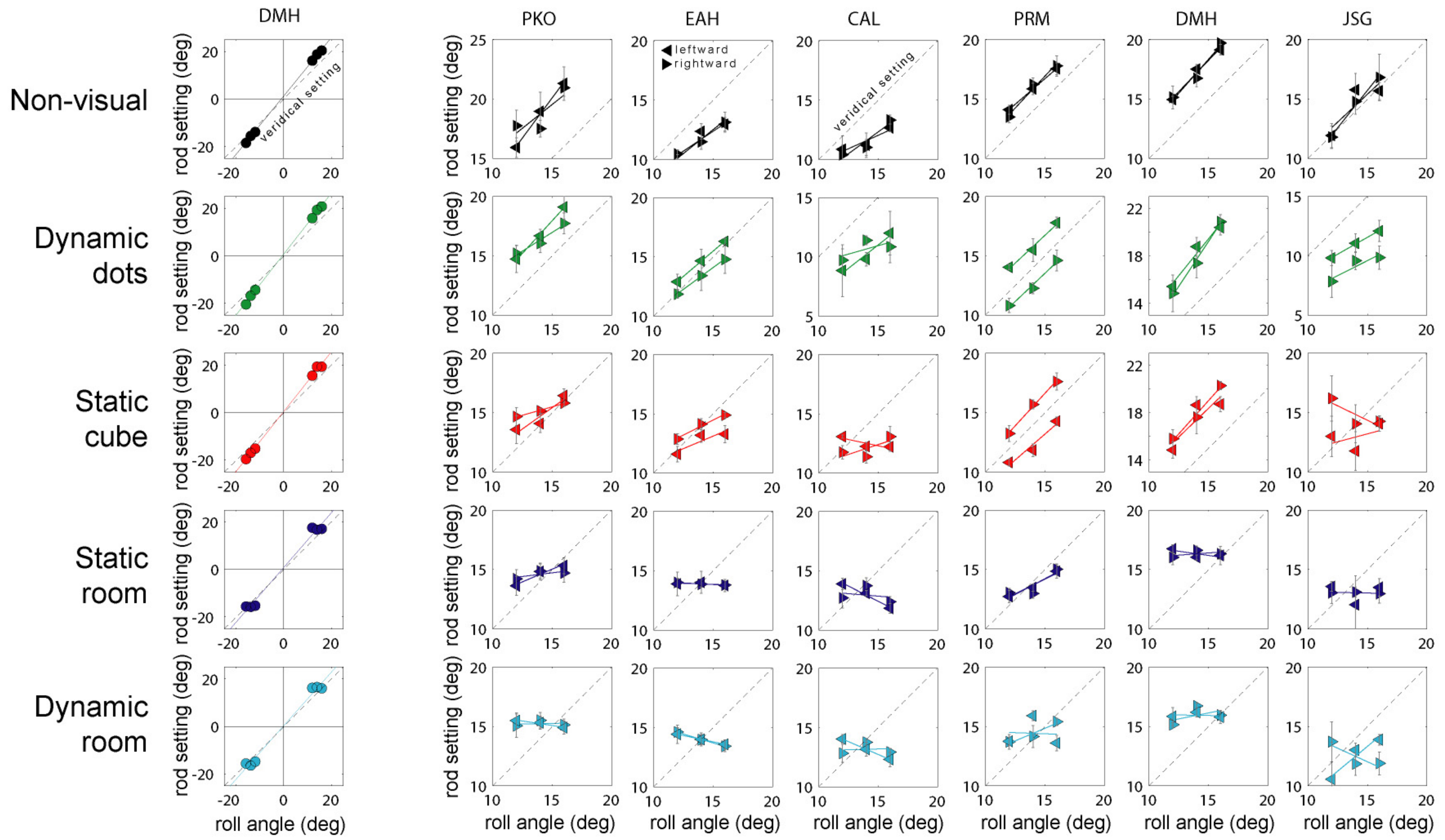
RESULTS



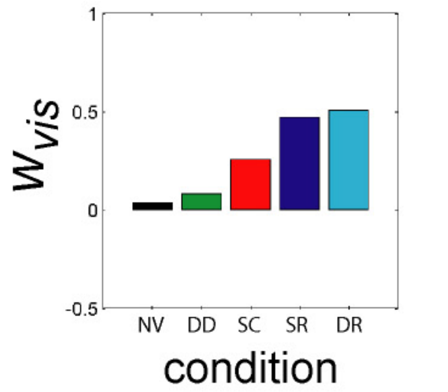
Bayesian estimate can be written as a weighted sum: $O_{comb} = w_{vest}O_{vest} + w_{vis}O_{vis} + w_{prior}O_{prior}$

Weights are proportional to variance: $w_i = 1/\sigma_i^2 \,/\, \sum_j 1/\sigma_j^2$

Weights sum to 1: $w_{vest} + w_{vis} + w_{prior} = 1$

We can solve for w_{vis} and w_{vest} if we assume: 1) unbiased sensory estimates 2) w_{prior} is small

Average visual weights



Visual weights calculated from average slopes