Evidence for both retinocentric and headcentric maps, but not body or world-centric maps in visual perception.

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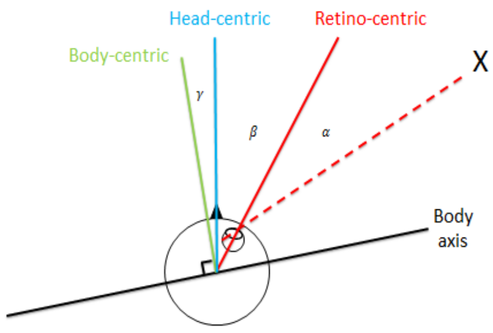
Introduction

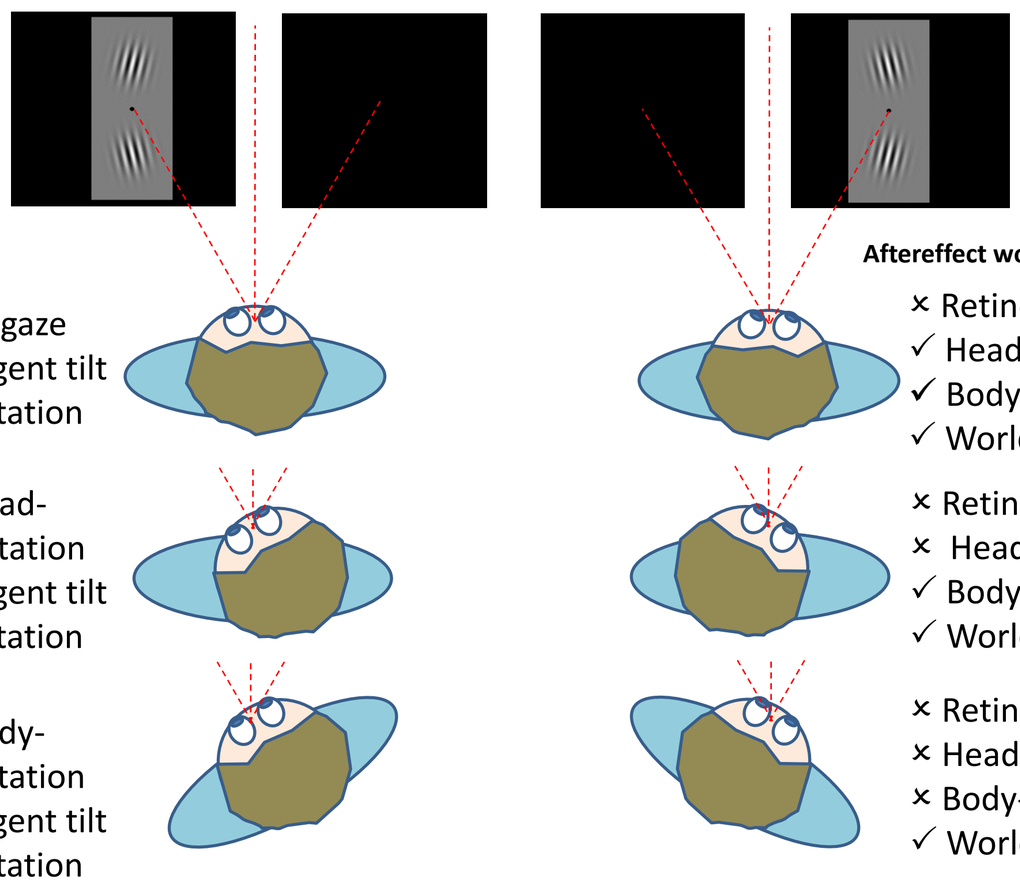
It is well established that retino-centric maps of the visual world exist, but these cannot enable a stable visual representation of the world despite rapid eye-, head-, and body-movement and are insufficient for visually guided action.

One possibility is that the visual system uses retinal information to create higher-level maps (head-centric, body-centric or world-centric). Here we test for the existence of such maps.



Experiment 1

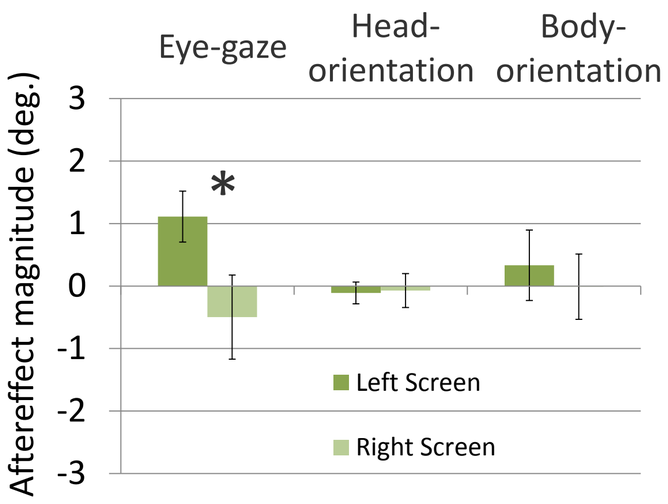
We examined the tilt aftereffect (TAE) using a balanced adaptation procedure to test for evidence of head-, body- and world-centric maps.



Screen location: d = 114cm, ±30˚
Adaptation stimulus: 100% contrast, 10 sec., Left Screen: +15˚ tilt, Right Screen: -15˚ tilt, sinusoidally oscillating
Test stimulus: 50% contrast, 0.1 sec., static

Physical alignment of head and body was measured with a Polhemus FASTRAK sensor/transmitter device.

Results



2 Factor repeated measures ANOVA
Direction * Viewing Condition:
$F_{2,18} = 3.717$, $p = 0.045$

T-Tests (2-tailed)
Eye-gaze contingent:
$t_9 = 2.591$, $p = 0.029$
Head-orientation contingent:
$t_9 = -0.121$, $p = 0.906$, n.s.
Body-orientation contingent:
$t_9 = 0.379$, $p = 0.713$, n.s.

Conclusions

The tilt-aftereffect is contingent on eye-gaze direction, suggesting a map beyond the retino-centric level.

Head-orientation and body-orientation conditions revealed no evidence for a body- or world-centric map.

These results are evidence that feature orientation is represented in a head-centric map, but not a body- or world-centric map.

These results are in contrast to recent work which found no evidence of maps beyond the retino-centric level (Knapen et al (2010). The reference frame of the tilt aftereffect. *Journal of Vision*. 10(1):8, 1–13)

Experiment 2

The TAEs found in Experiment 1 may be explained by adaptation of tilt sensitive units which are modulated by eye-gaze direction ("gain fields" of units such as those found by Trotter & Celebrini (1999). Nature. 239-242 in macaques). In Experiment 2 we examined:

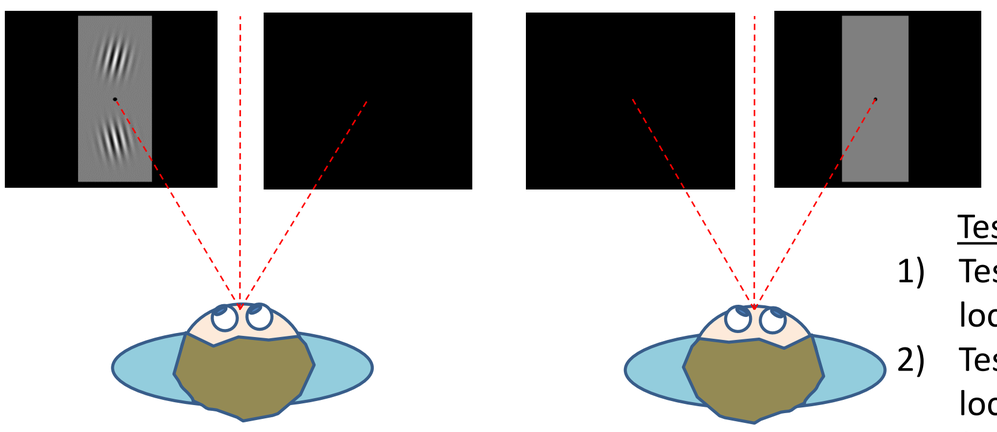
- Whether the conventional TAE can be explained by adaptation of two separate processes: 1) an aftereffect of retino-centric tilt and 2) an aftereffect of the eye-gaze modulation process.
- Whether the two types aftereffects have different temporal characteristics (0.05 sec., 0.15 sec., 0.45 sec.).

Condition 1: Balanced tilt adaptation

Eye-gaze contingent tilt adaptation (as in Experiment 1)

Prediction: TAE due to eye-gaze modulation

Condition 2: Tilt adaptation at one location only

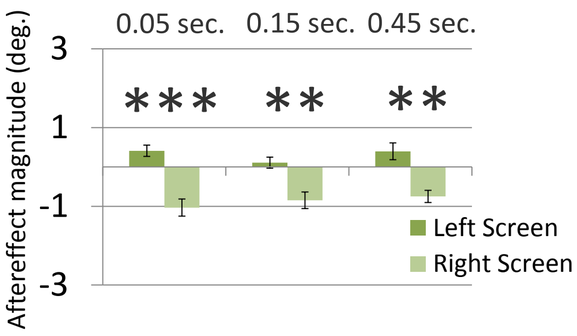


Test conditions:
1) Test at adapted location ("Same")
2) Test at unadapted location ("Different")

Prediction: Conventional TAE (Condition 2 "Same") = TAE due to eye-gaze modulation (Condition 1 Balanced tilt adaptation) + TAE due to tilt (Condition 2 "Different")

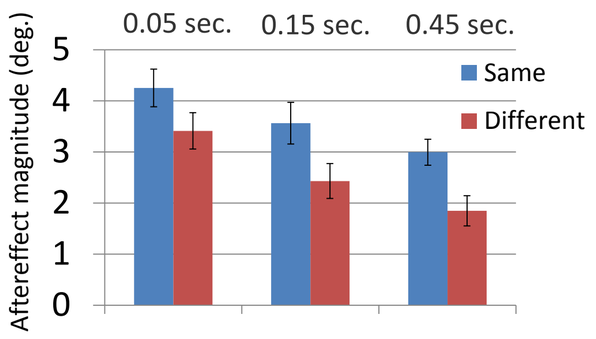
Results

Condition 1: Balanced tilt adaptation (N=10)



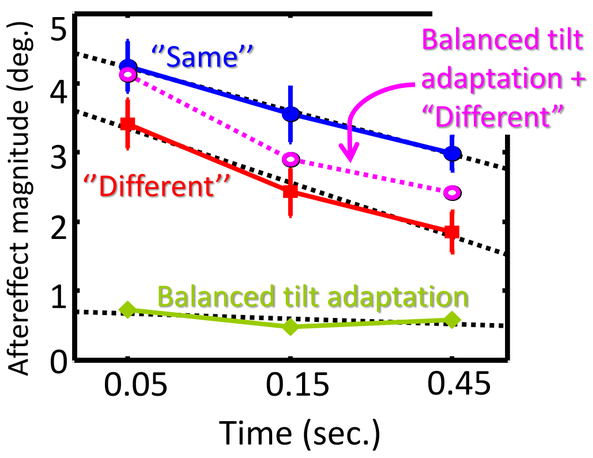
2 Factor repeated measures ANOVA
Direction * Duration:
$F_{2,18} = 2.340$, $p = 0.125$, n.s.

Condition 2: Tilt adaptation at one location only (N=10)

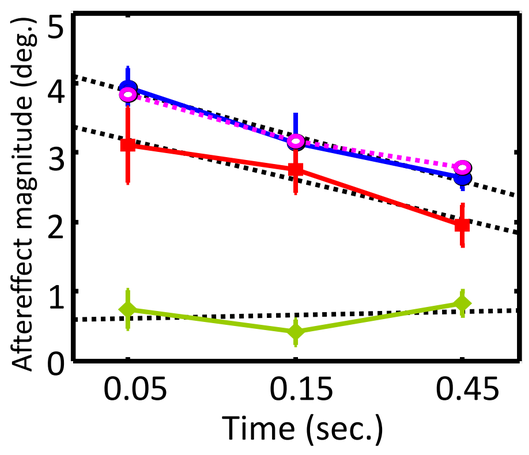


2 Factor repeated measures ANOVA
Duration: $F_{2,18} = 16.149$, $p < 0.0005$
"Same" vs. "Different": $F_{1,9} = 10.089$, $p = 0.011$

Condition 1 & 2



Condition 1 & 2, Repeated measures, N=4



2 Factor repeated measure ANOVA
Balanced tilt adaptation + "Different" vs. "Same":
$F_{1,9} = 1.868$, $p = 0.205$, n.s.

Summary & Conclusions

The TAE is contingent on eye-gaze direction, but not head- or body-direction, suggesting a head-centric map.

The conventional TAE is the result of adaptation of two independent processes: a tilt encoding process and an eye-gaze encoding process. This fits with 'gain field' behaviour of primate V1 neurons.

The tilt sensitive process is sensitive to test stimulus duration, but the eye-gaze modulation process is not.