Adaptation of catch-up saccades during smooth pursuit initiation

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Background

Saccades and of smooth pursuit eye movements are known to adapt to target steps[1] and to predictable target velocity[2] changes respectively.

However, we do not know if both systems cooperate when adapting to targeting errors.

In a short-term adaptation paradigm, we tested the effect of target steps introduced during the first catch-up saccade that is made during initiation of smooth pursuit.

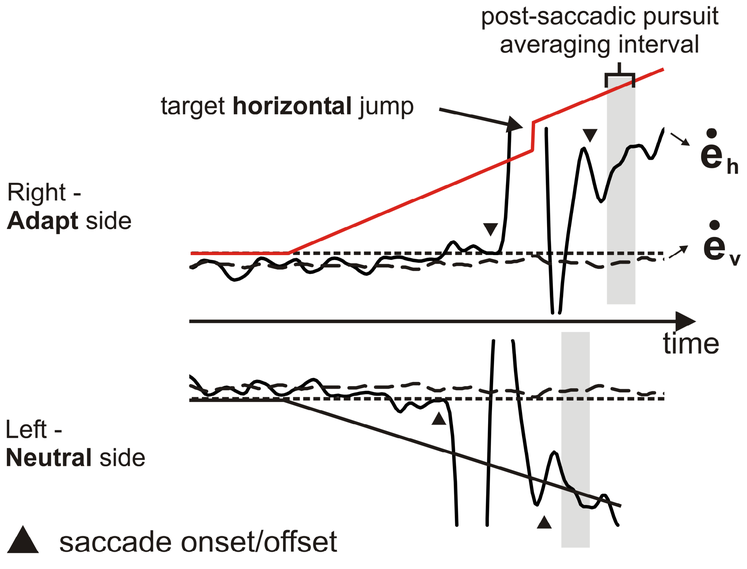
Methods

Subjects task was to pursue a target moving at 22 or 11 deg/sec in a randomized direction.
In the adaptation phase, **rightward** targets are **displaced** (25% of saccade size, M= 0.7° and 1.3° for 22 and 11 deg/sec ramps) in the direction (**forward** condition) or opposite (**backward** condition) to motion direction, during the first *catch-up* saccade.

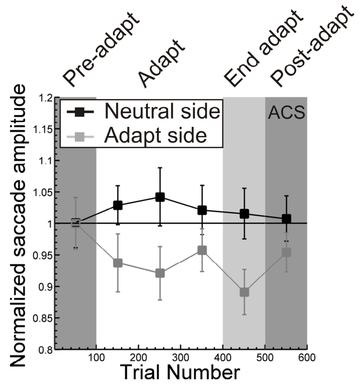
Adaptation paradigm:

100 pre trials | 400 adaptation trials | 100 post trials

Sample trial

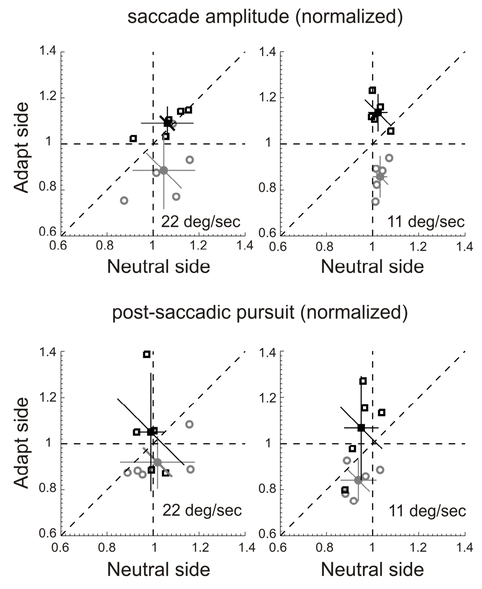


Adaptation along pursuit axis



Adaptation of saccade amplitude and of pursuit post-saccadic velocity.
Values are normalized to pre-adaptation phase values in the backward (○) and forward (□) step conditions.
Catch-up saccade adaptation is clear for backward conditions and in the forward 11 deg/sec condition.
There is significant pursuit velocity adaptation to backward steps with the 11 deg/sec ramp.

Adaptation time course and averaging interval.
Saccade adaptation can take place over a few tenths of trials at most.
In further analysis, Adapt and Neutral side values are compared at the end of the adaptation phase (last 100 trials).



Summary

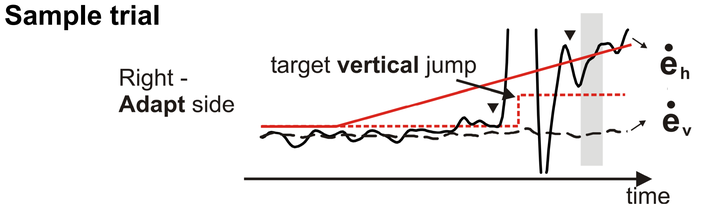
- ❑ Even catch-up saccades – small (<1° for 11 deg/sec speed) and of variable size – can adapt rapidly to position errors
- ❑ Post-saccadic pursuit can also compensate for position errors generated by backward steps (forward adaptation is smaller)
- ❑ The cross-axis adaptation experiment shows idiosyncratic compensations by modification of pursuit velocity or saccade end trajectory

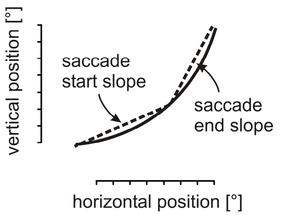
There is a synergy between the saccadic and pursuit system for correcting visual position errors over a few tenths of trials.

Cross-axis adaptation

Methods. Displacement in the vertical direction: 25% or 50% of the predicted saccade size (M=0.7° and 1.4°). Saccade trajectory and vertical pursuit velocity were analyzed.

Sample trial





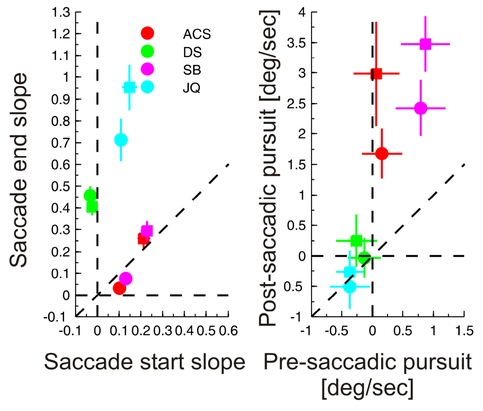
Saccade curvature. The end of the saccade sometimes compensates more for the vertical visual error than the initial part.

Pursuit and saccadic adaptation.

Subjects adapt to the vertical error either by adjusting the end of the saccade trajectory or by a higher post-saccadic velocity of the vertical pursuit component.

Circles = 25% step

Squares = 50% step.



References

[1] Hopp JJ, and Fuchs AF. The characteristics and neuronal substrate of saccadic eye movement plasticity. *Prog Neurobiol 72: 27-53, 2004.*

[2] Ogawa T, and Fujita M. Adaptive modifications of human postsaccadic pursuit eye movements induced by a step-ramp-ramp paradigm. *Experimental brain research 116: 83-96, 1997.*

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