Eyeshots Tutorial
Eye movements in space perception

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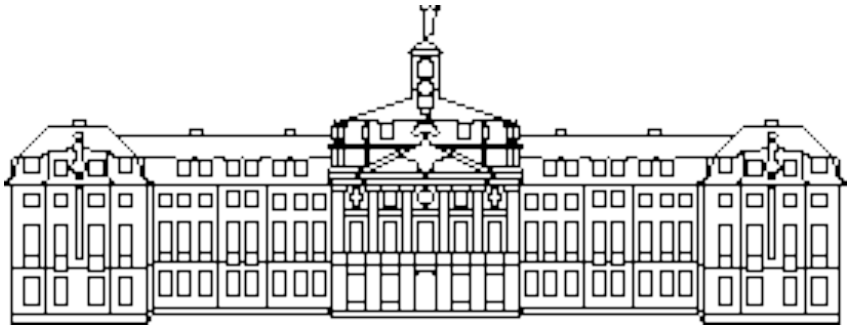


Workparts

- Motor descriptors of space
- Predicting attention / hand movement from gaze
- Shared attention

Scene perception

Change blindness

Workparts

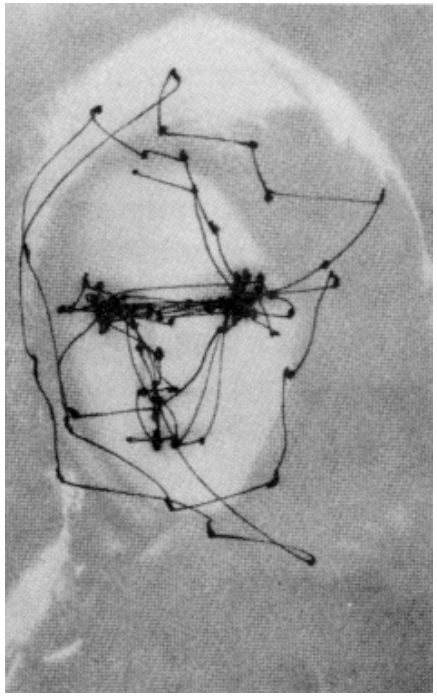
- Motor descriptors of space
- Predicting attention / hand movement from gaze
- Shared attention

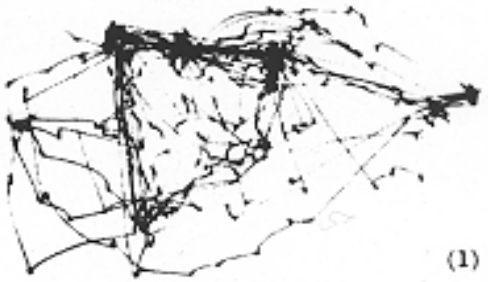
Eyeshots Tutorial
Eye movements in space perception

- Eye movements in natural tasks
- Eye movements in human interaction
- The problem of spatial stability
- Visual and extraretinal cues for localization
- Saccadic adapation and localization
- Motor descriptors of spatial location

Eye Movements

Scene Understanding

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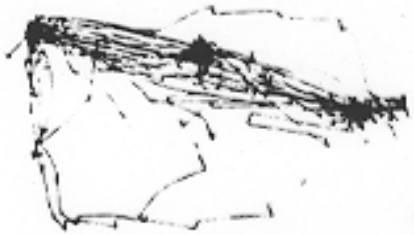
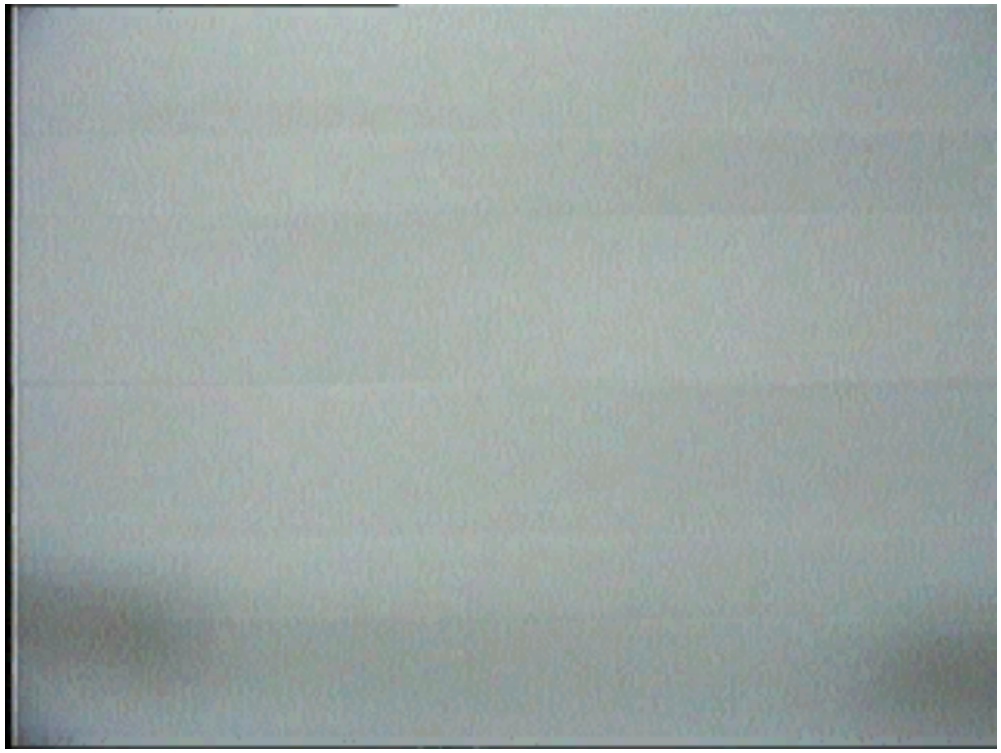
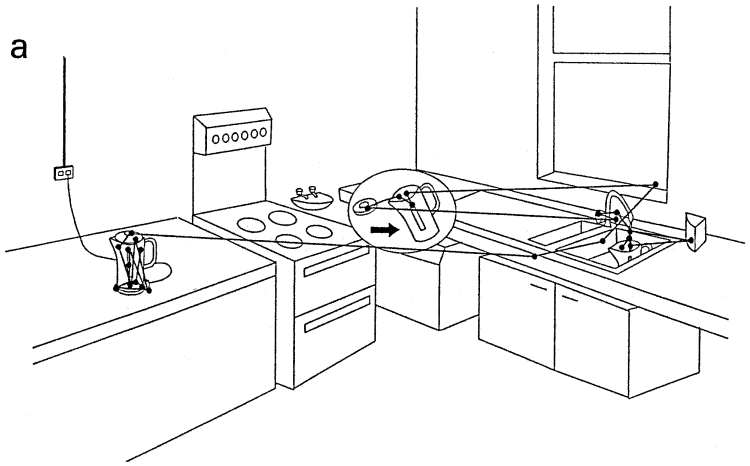

(7)

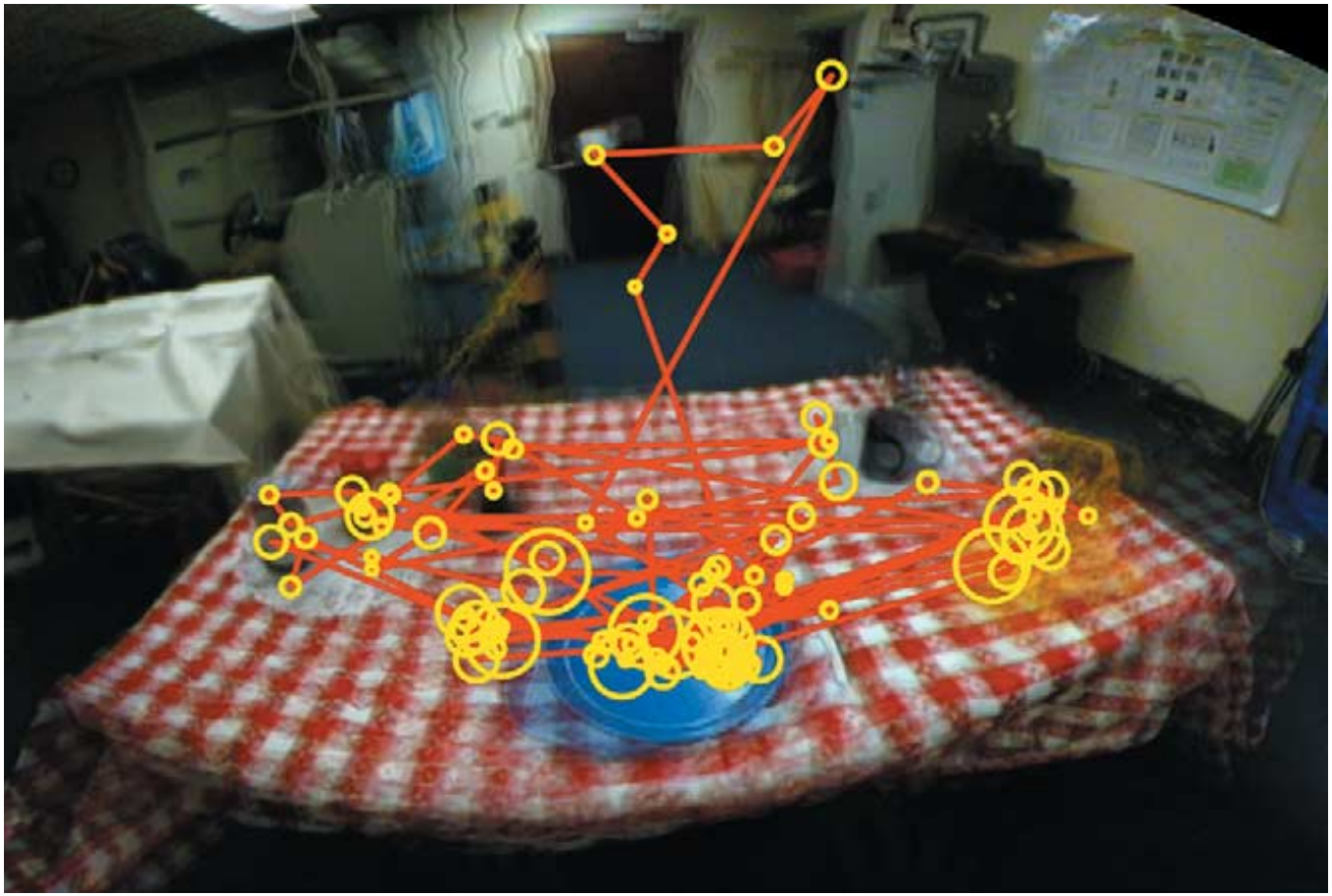
Eye movements in natural tasks





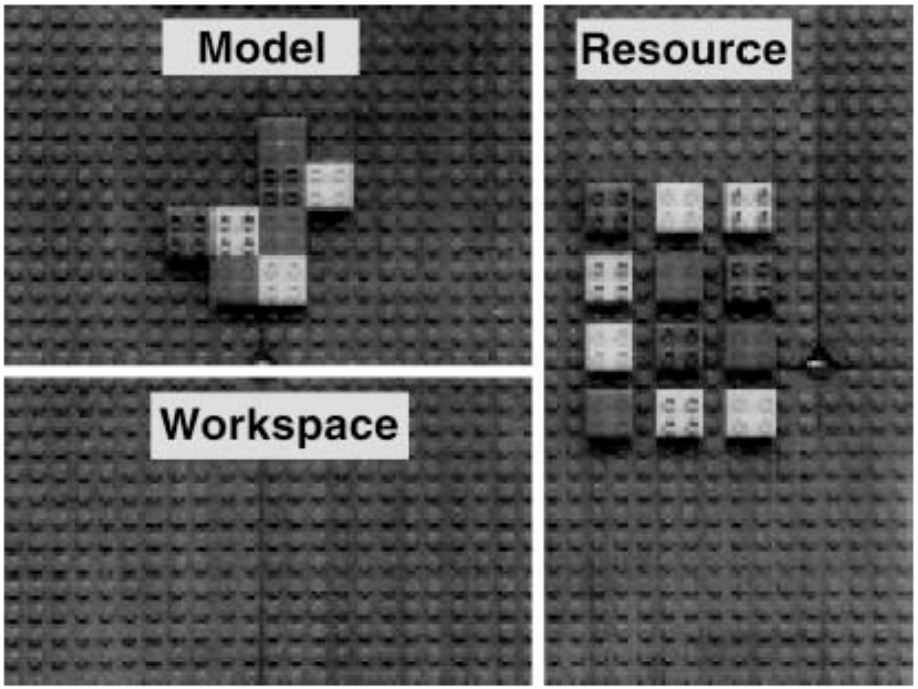
Land & Hayhoe, Vis.Rs., 2001

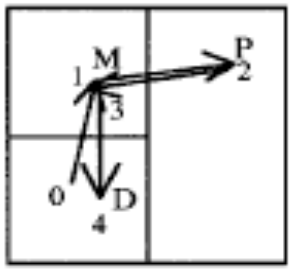
Eye movements in natural tasks

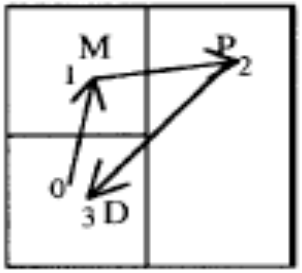


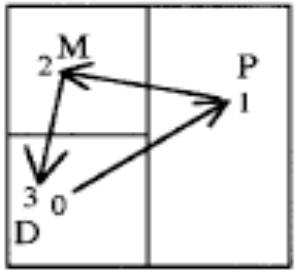
Land & Hayhoe, Vis.Rs., 2001

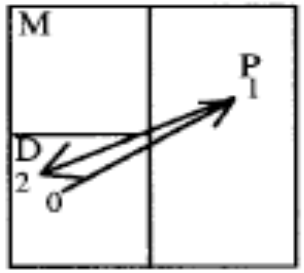
The world as external memory







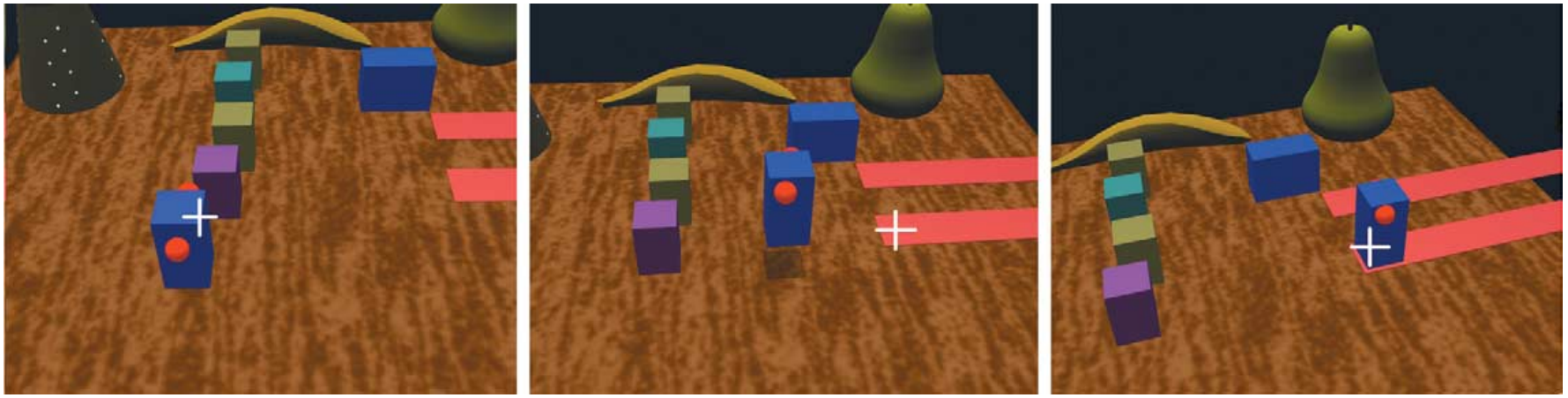




Here blocks may transiently disappear in one condition

Ballard et al., J. Cog. Neurosci., 1995
Karn & Hayhoe, Visual Cognition, 2000

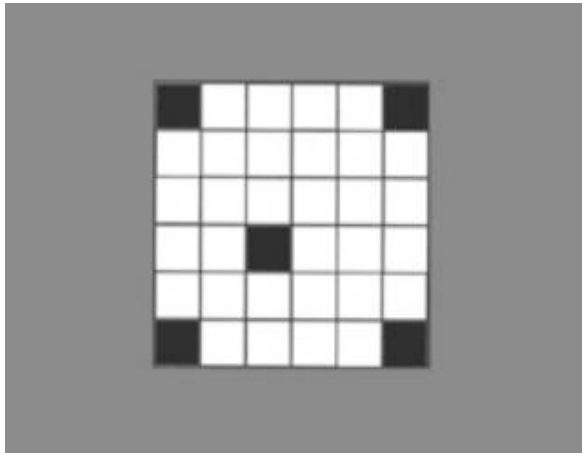
The world as external memory



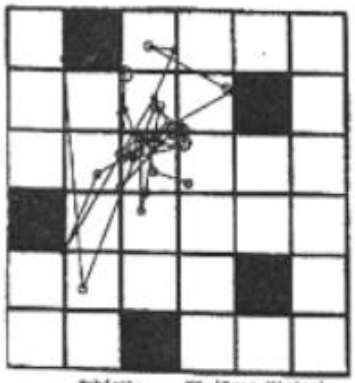
A reviewer of the project

Triesch et al. J. Vis. 2003

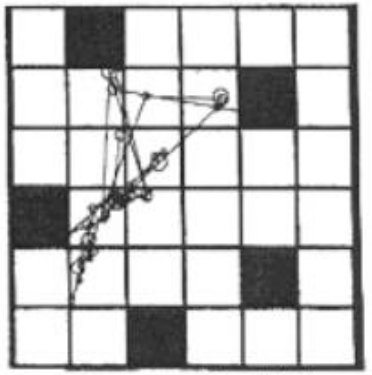
Eye movments in memory retrieval

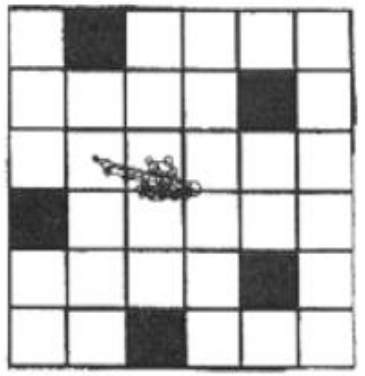


Viewing



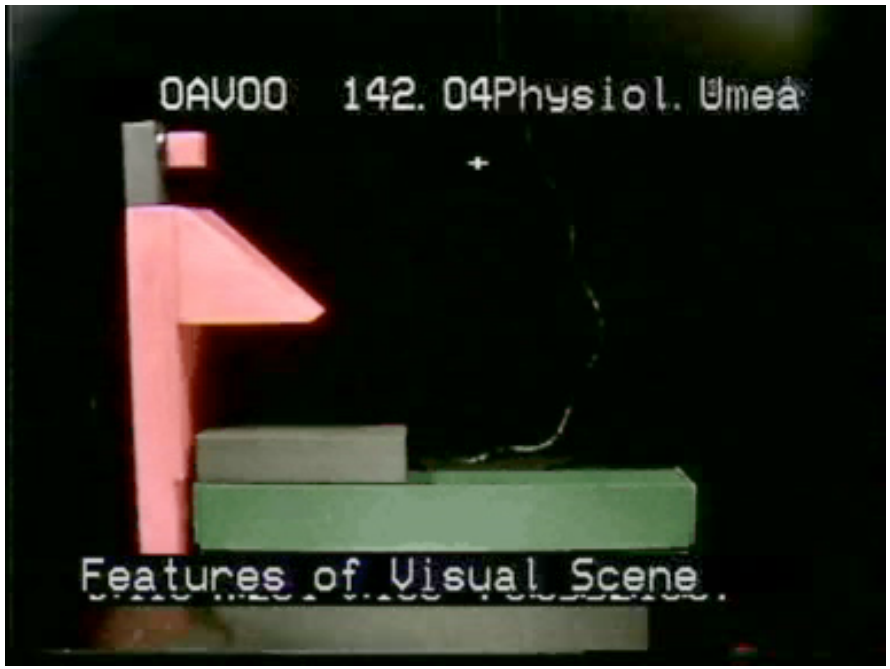
Imagining

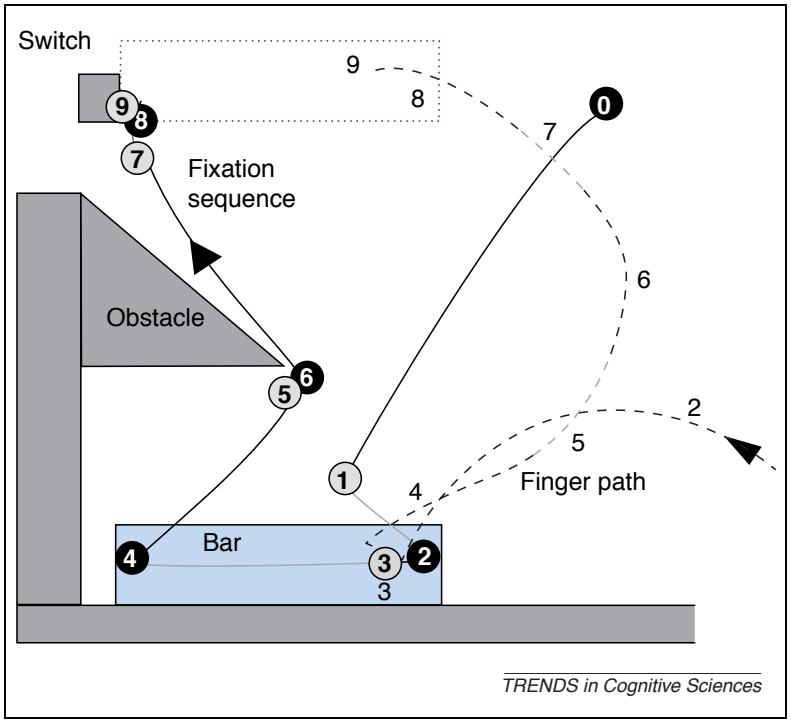




Richardson & Spivey, Cognition, 2000

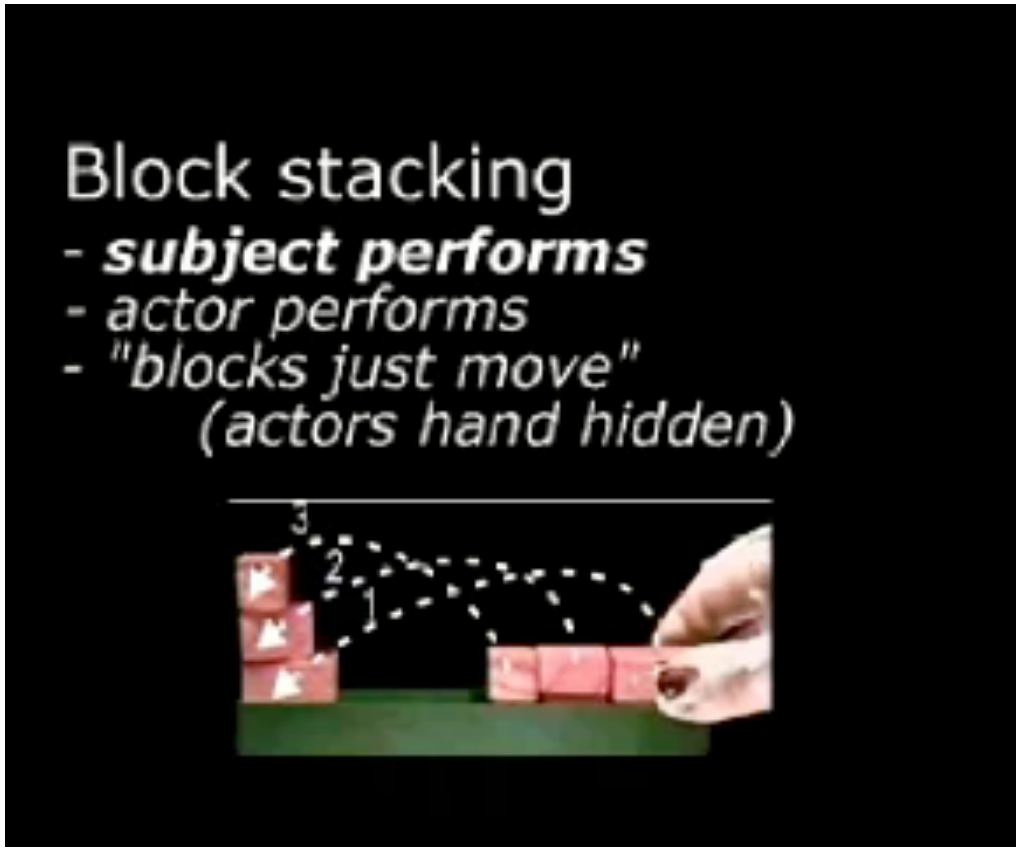
Eye-hand coordination





Flanagan et al., Nature, 2003

Action observation



Johansson et al. J. Neurosci. 2001

Attention cuing by gaze

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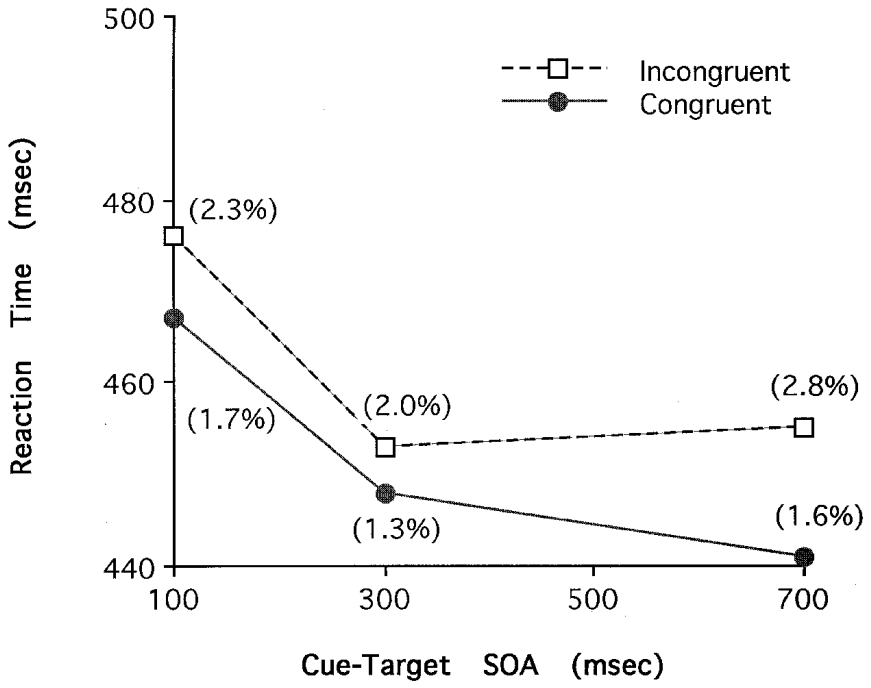
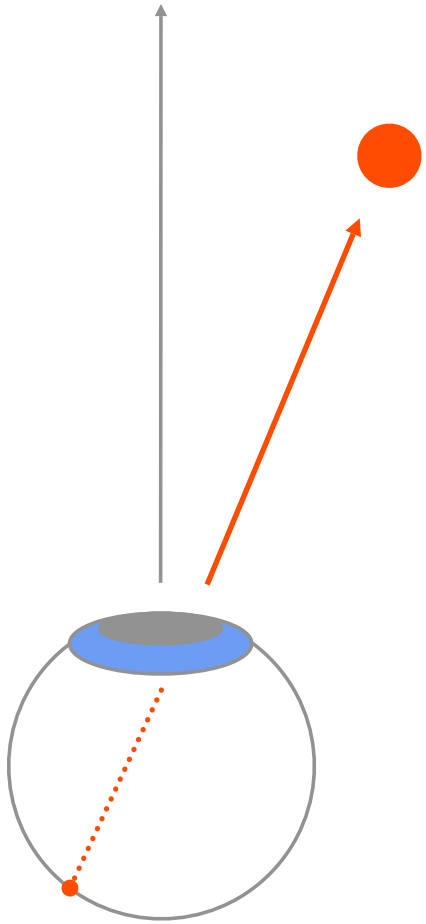


Driver et al., Visual Cognition, 1999

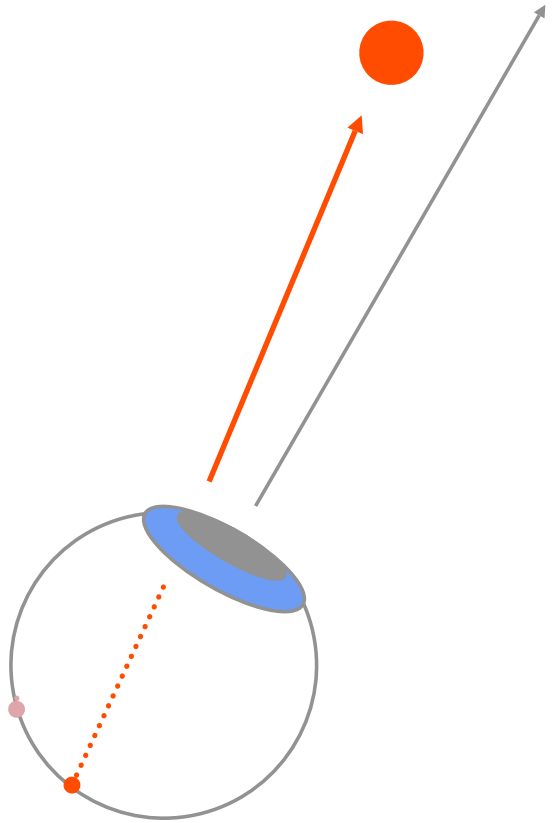
Workparts

- Motor descriptors of space
- Predicting attention / hand movement from gaze
- Shared attention

The problem of spatial stability



The problem of spatial stability



Stability of space

A. Use eye position or efference copy to compensate

B. Use the image, the world is stable

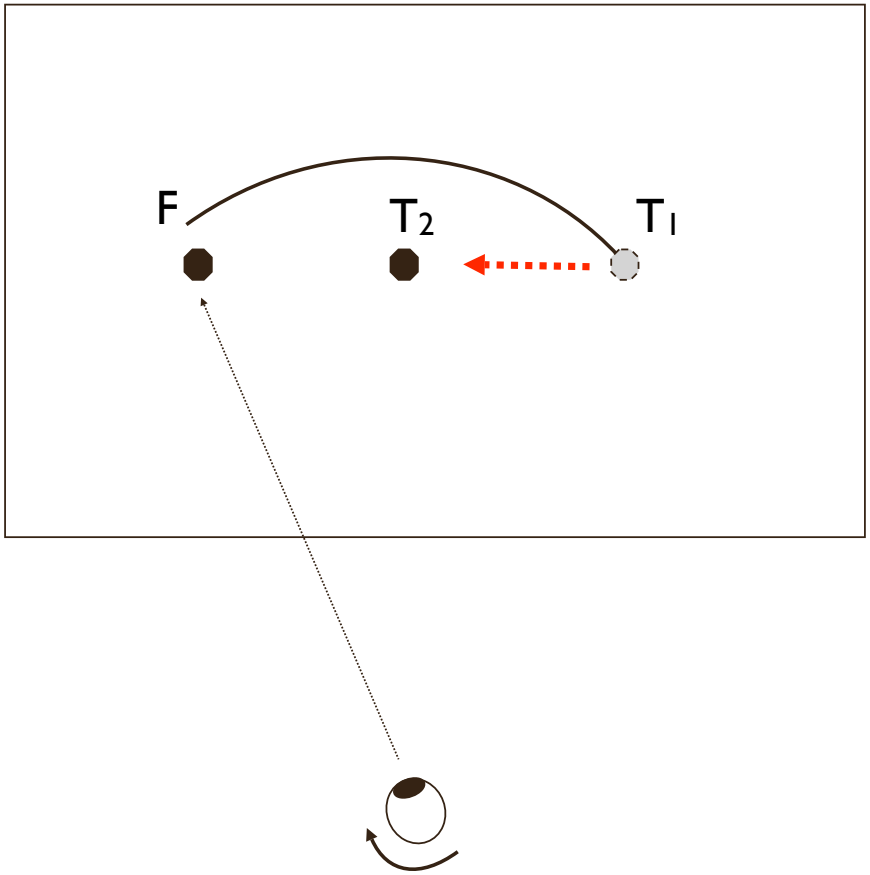
C. Forget about the problem: do everything fresh after each saccade

Saccadic mislocalization

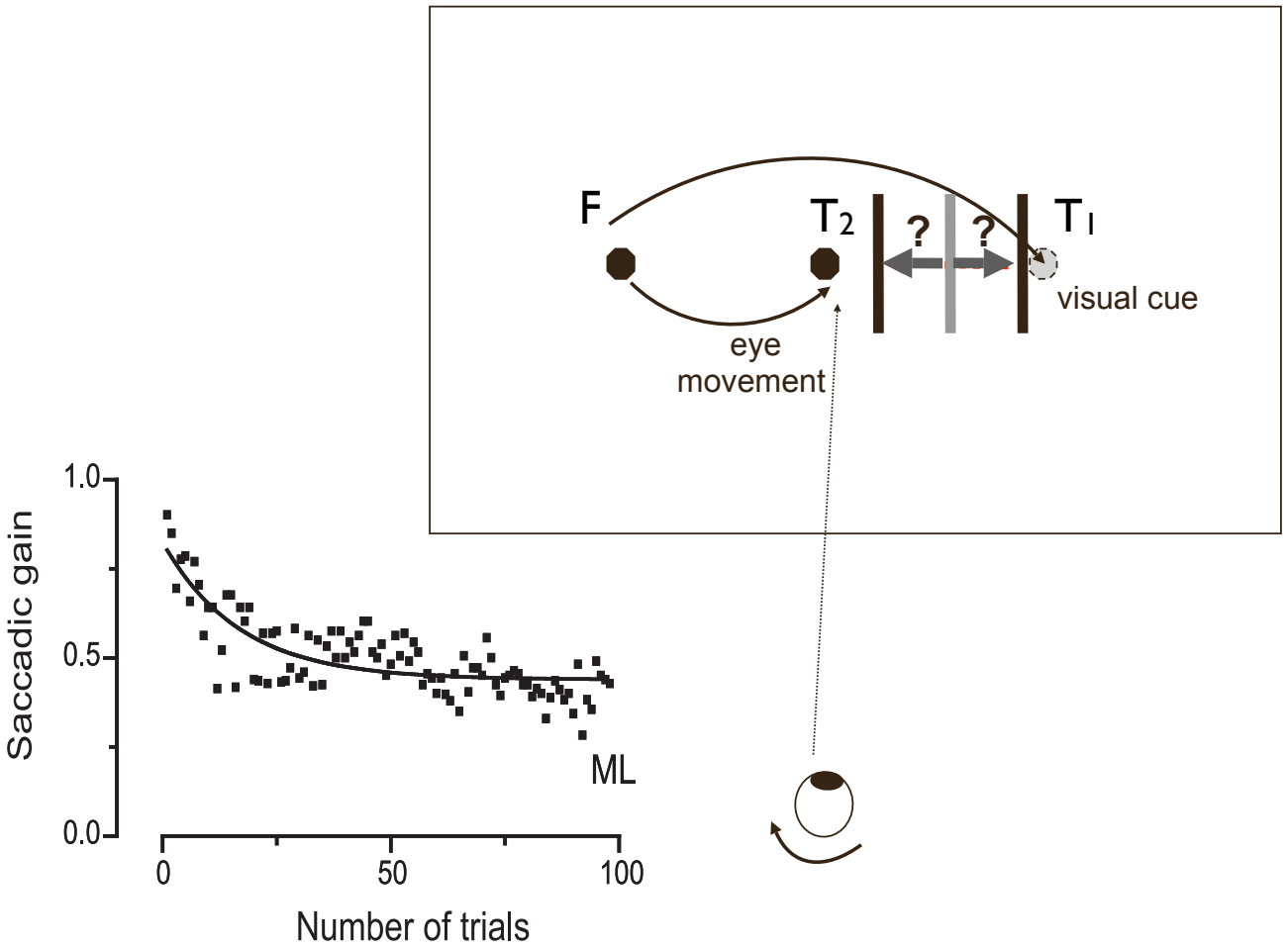
- Shift
- Compression
- Adaptation-induced shift

Way to study motor descriptors for spatial location

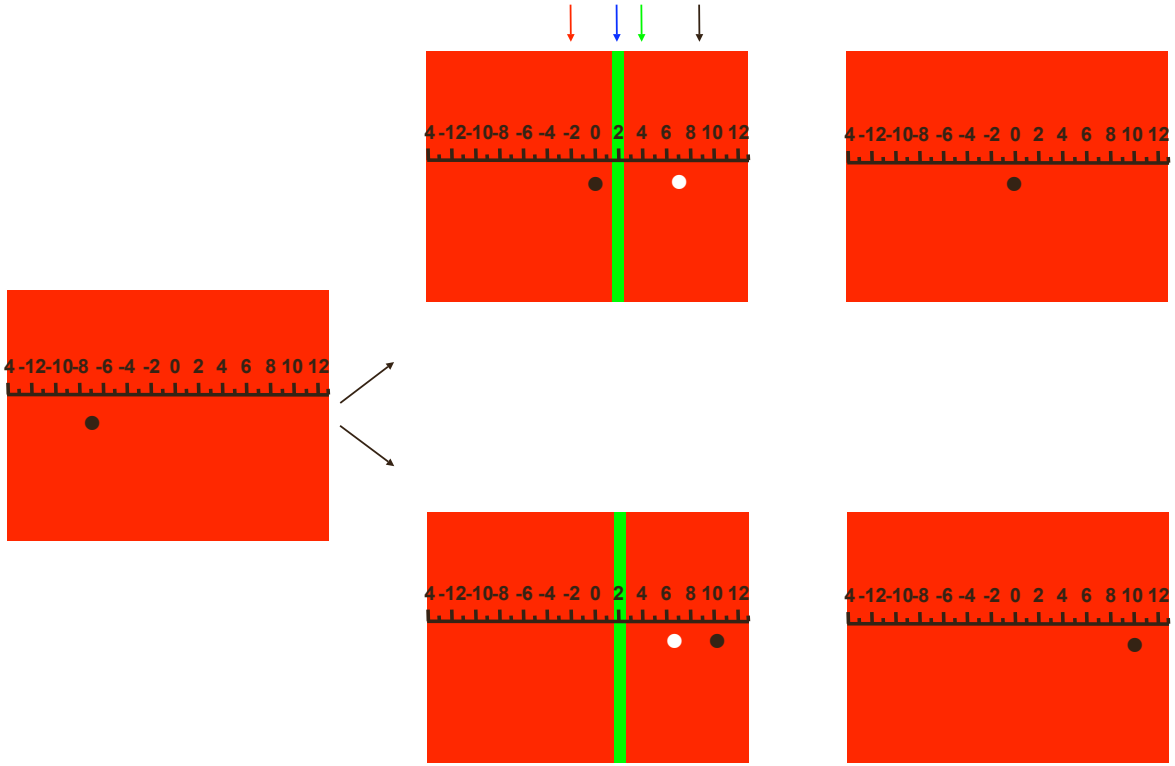
Saccade adaptation



Saccade adaptation



Method



gain decreasing:

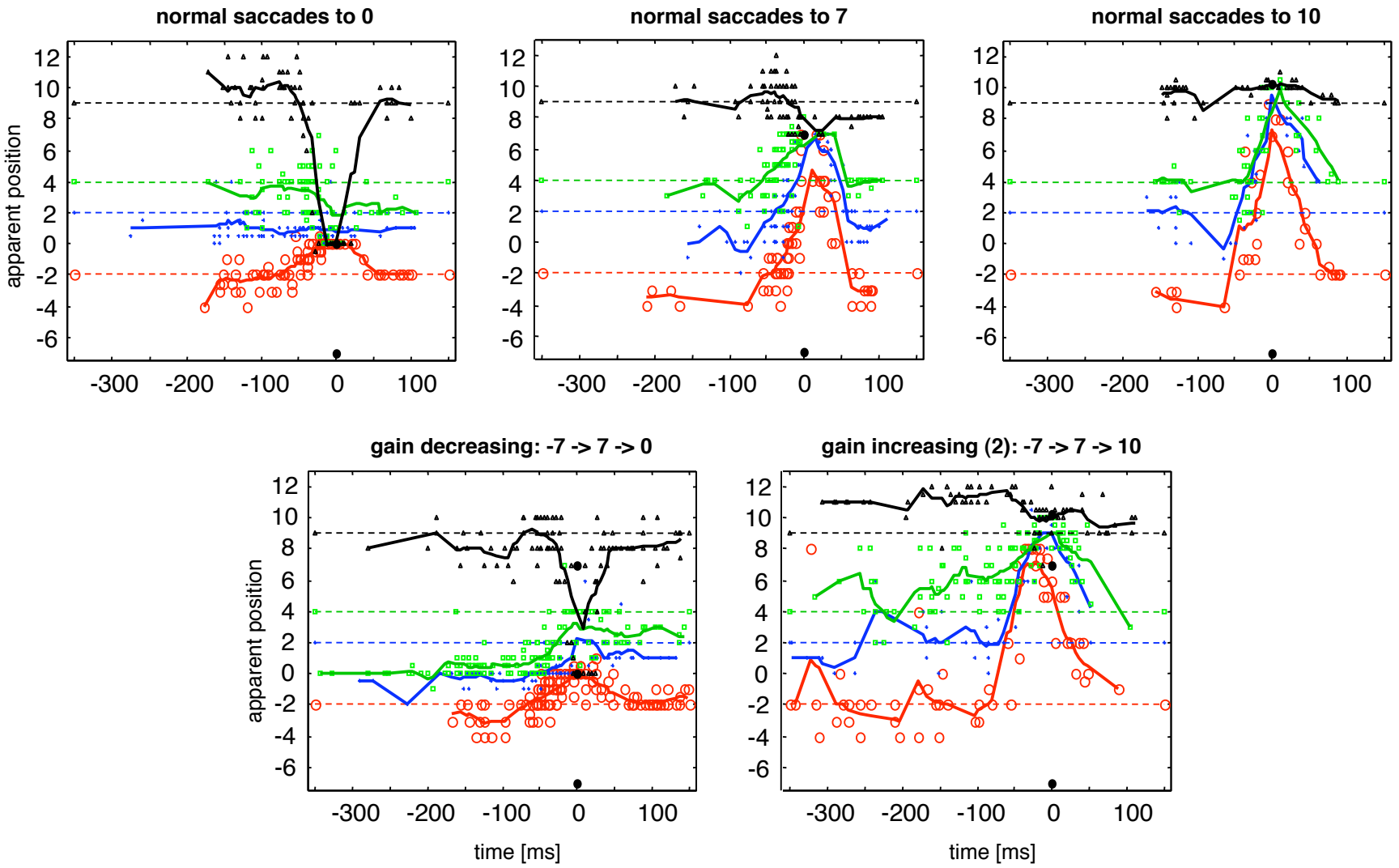
-7 -> 7 -> 0

gain increasing:

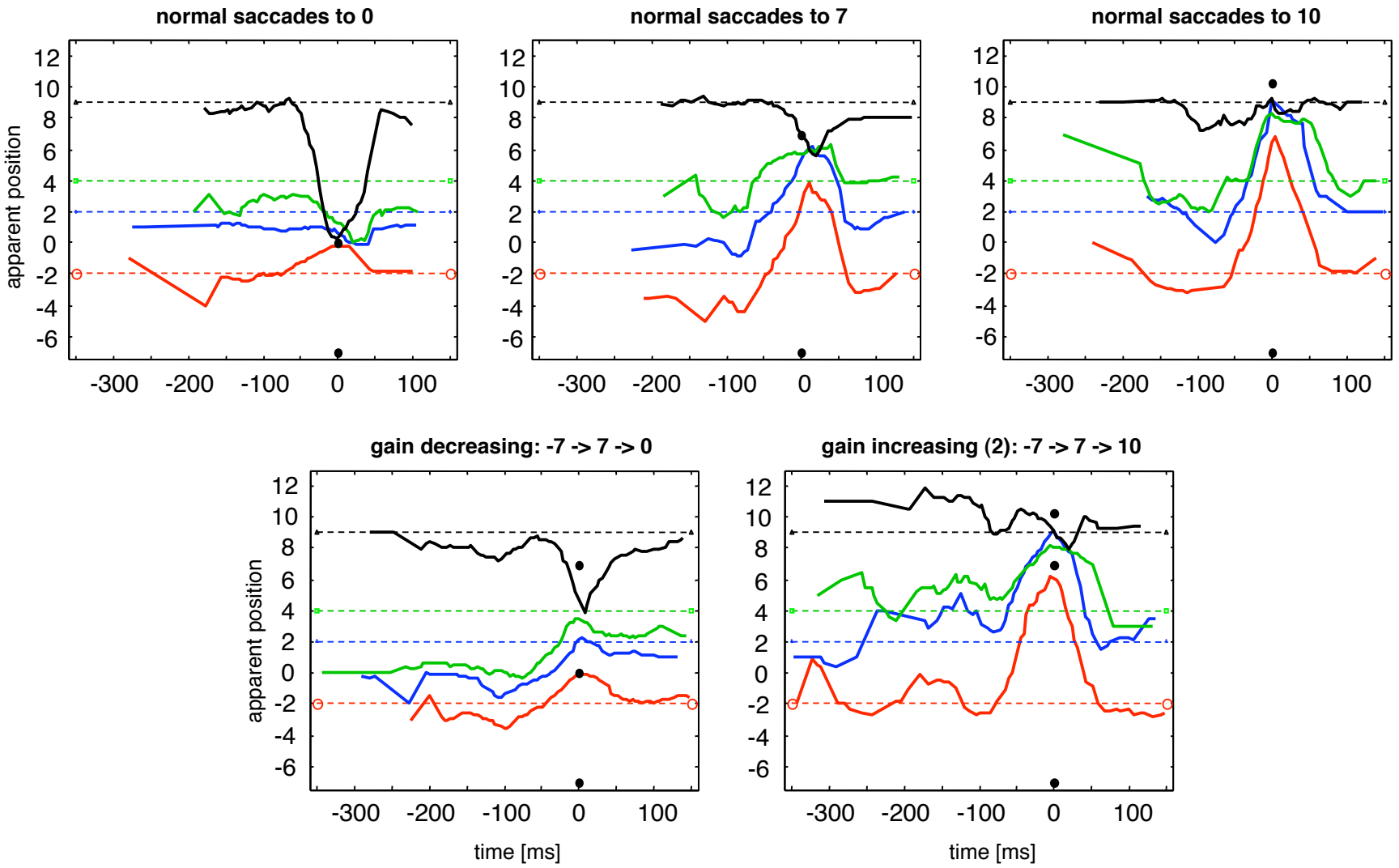
-7 -> 7 ->10

Awater, Burr, Lappe, Morrone, & Goldberg, J.Neurophysiol. 2005

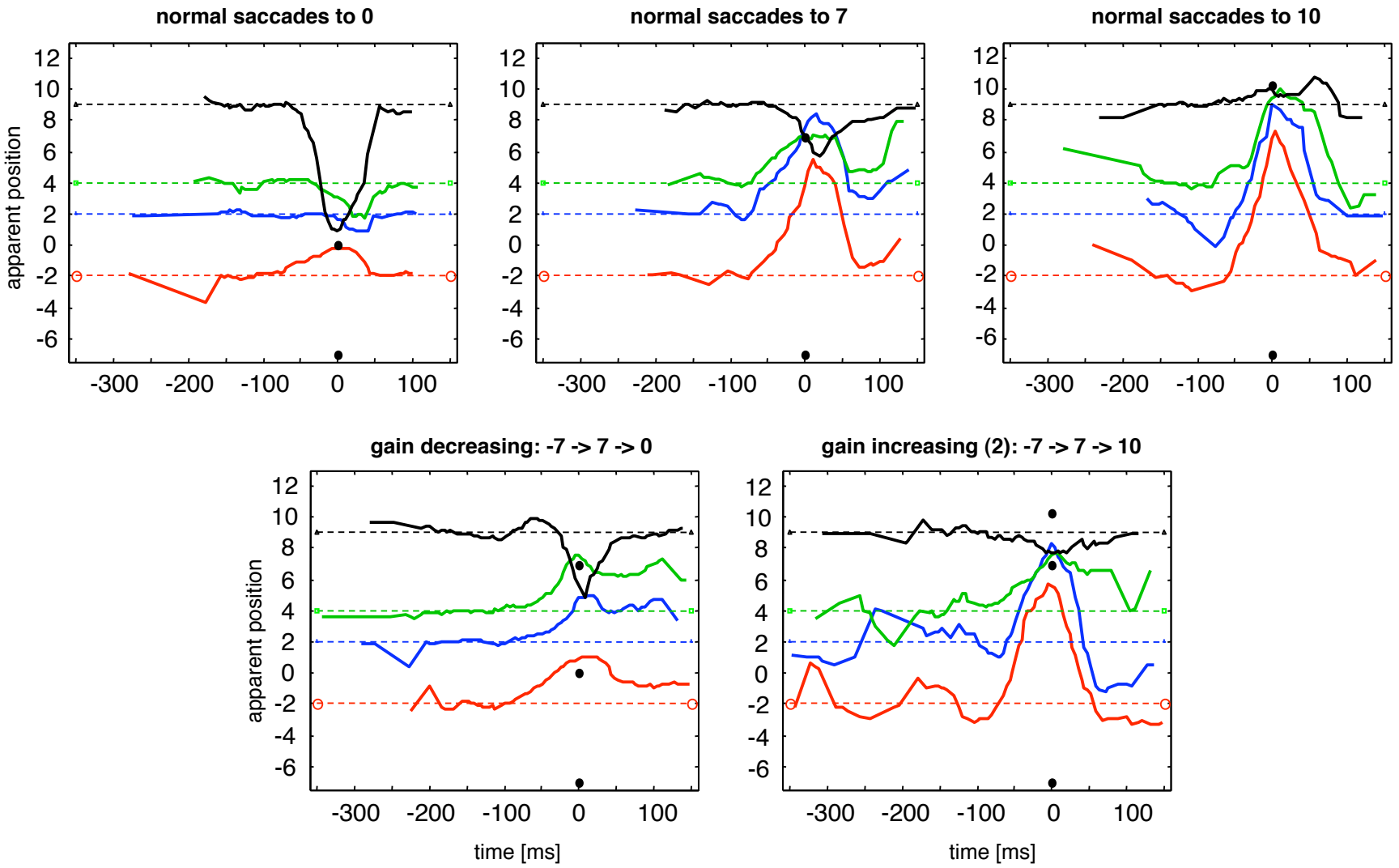
Mislocalization for normal and adapted saccades



Mislocalization for normal and adapted saccades



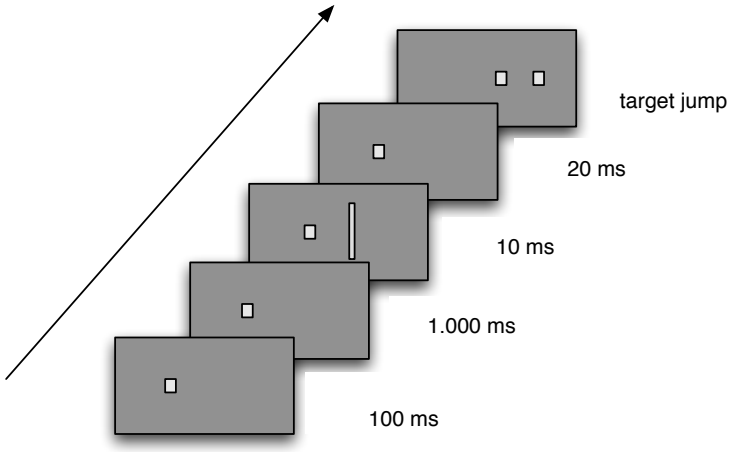
Mislocalization for normal and adapted saccades

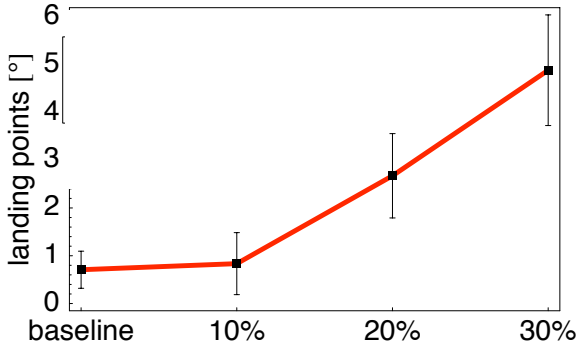


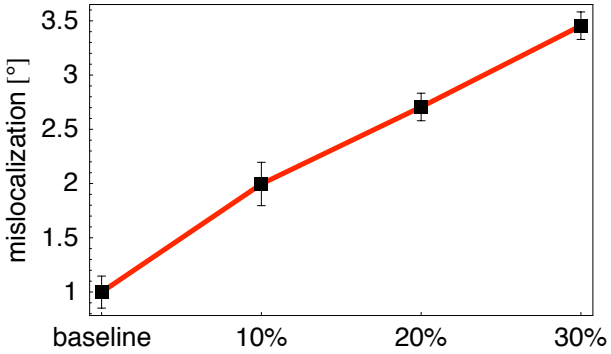
Mislocalization for adapted saccades

- Perisaccadic compression obtained with normal saccades also occurs with adapted saccades.
- In the adapted state, mislocalizations of flashed objects occur not only perisaccadically but also long before the saccade.
- These mislocalisations are position dependent: they occur mainly near the adapted space.
- The center of compression is influenced by the adaptation: absolute perceived positions fall near the landing point of the eye. When the baseline shift induced by the adaptation is subtracted, the compression is similar to the normal state.

Adaptation-induced shift





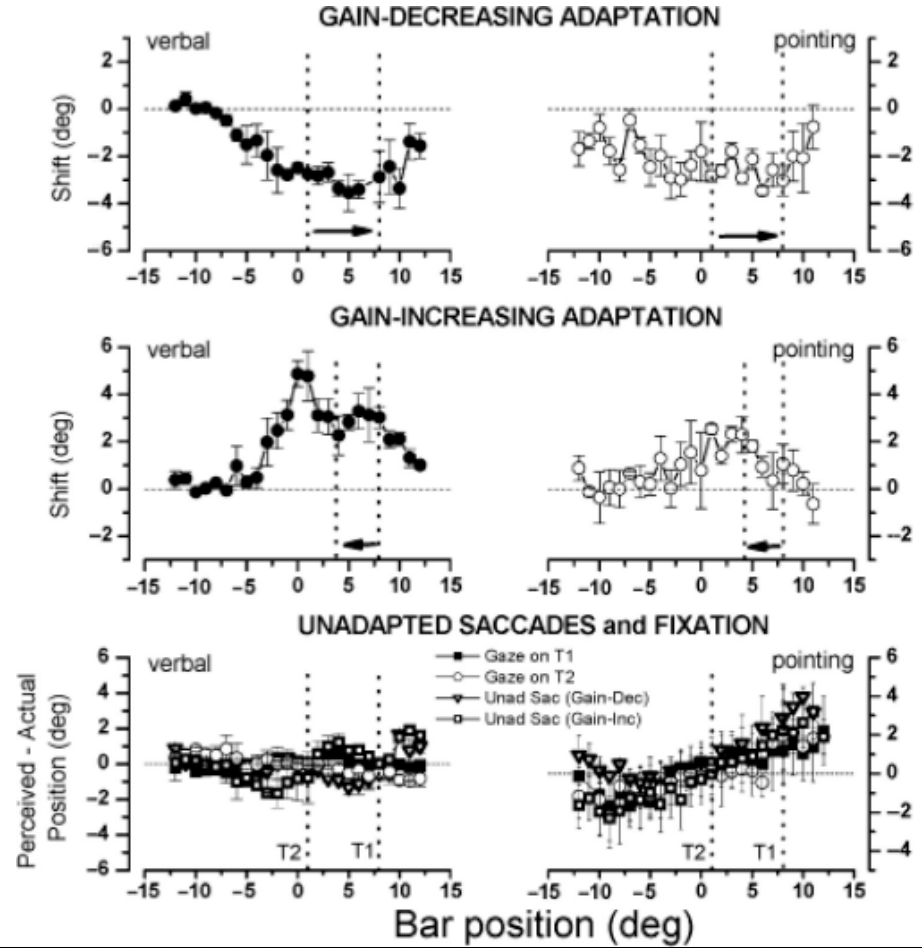


The adaptation-induced shift

- occurs long before the saccade
- ends at saccade end
- is independent of contrast

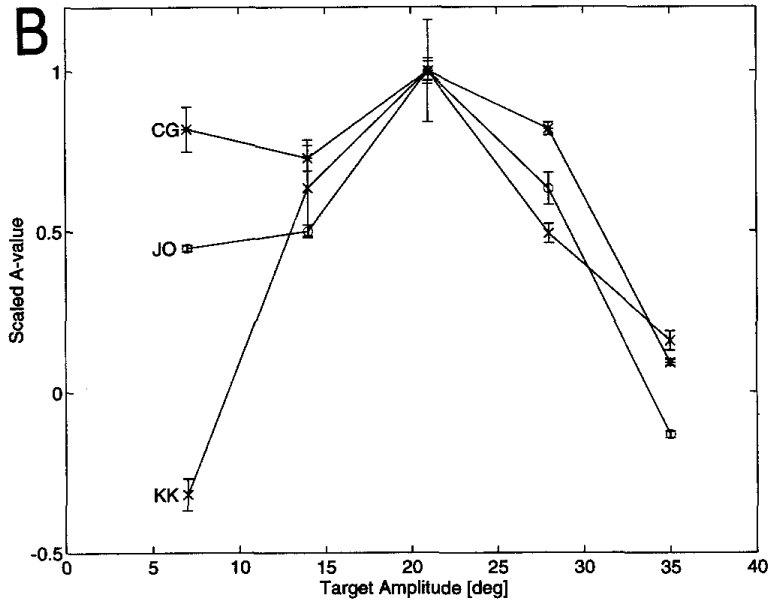
The adaptation-induced shift

- transfers to reaching

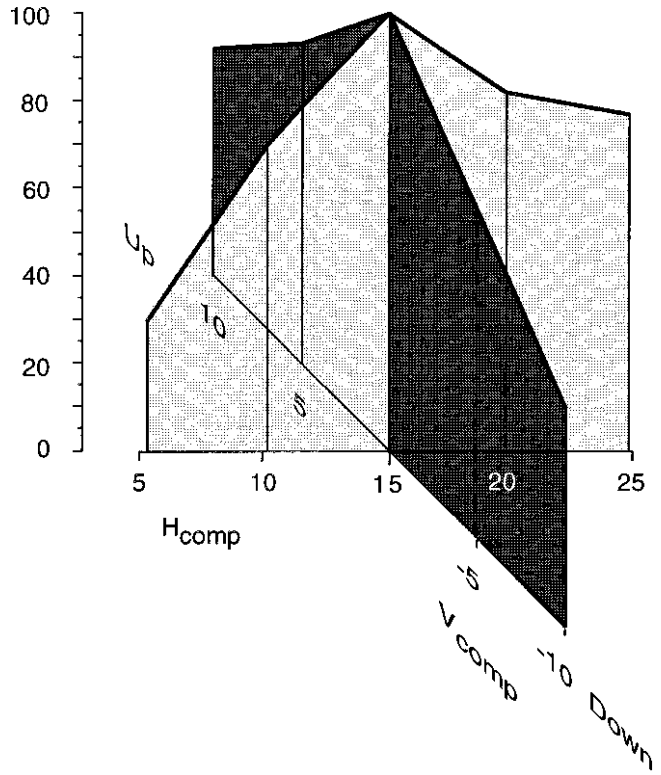


Bruno & Morrone, J.Vis. 2007

The saccade adaptation field



Frens & van Opstal, Exp. Brain Res. 1994

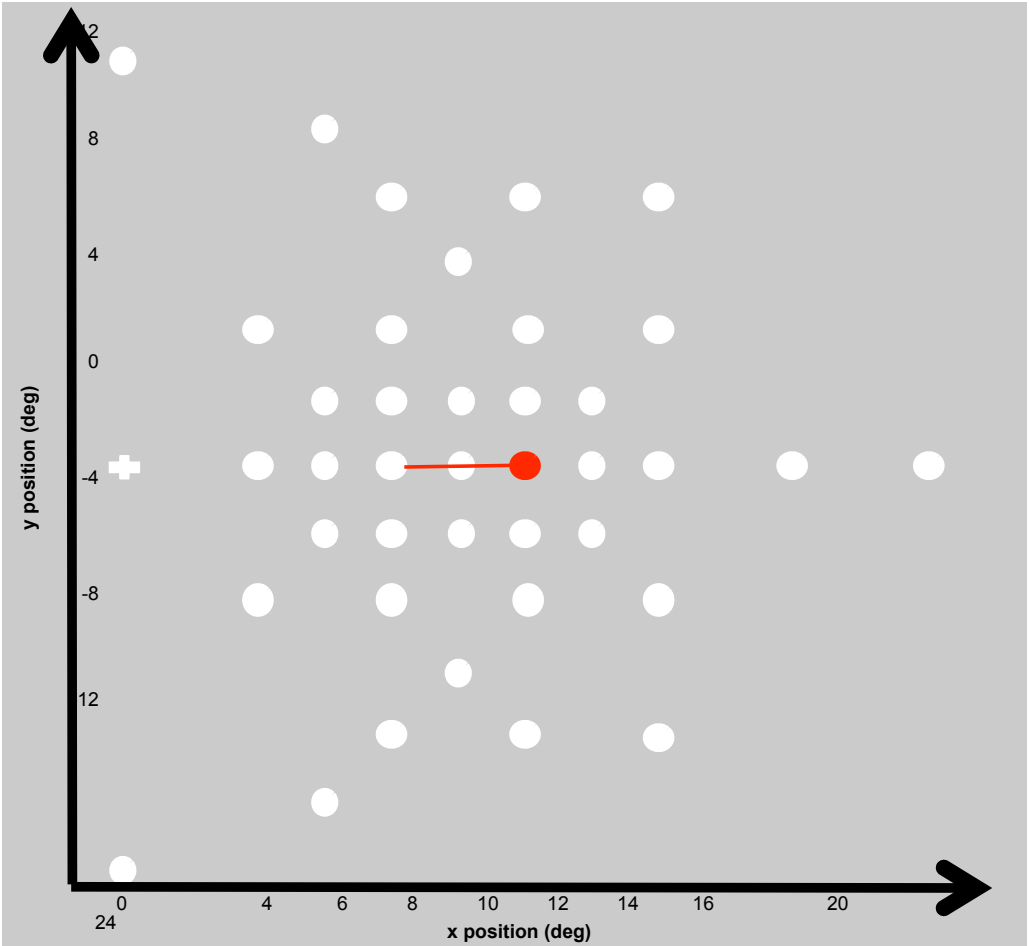


Noto, Watanabe & Fuchs, J. Neurophysiol. 1999

The saccade adaptation field

Four conditions:

1. Saccade
2. Step-back
3. No-step
4. Fixation



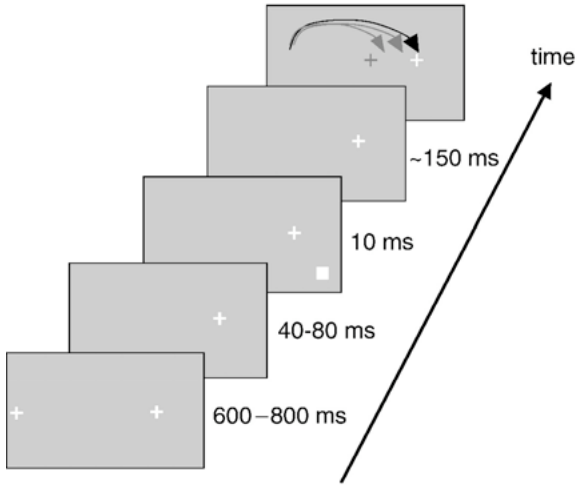
Collins, Dore-Mazars, & Lappe, Brain. Res. 2007

The saccade adaptation field

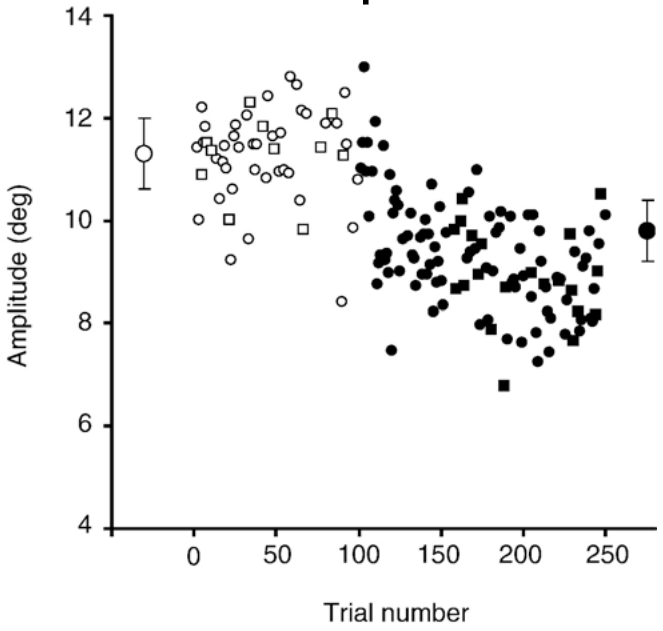
Four conditions:

1. Saccade
2. Step-back
3. No-step
4. Fixation

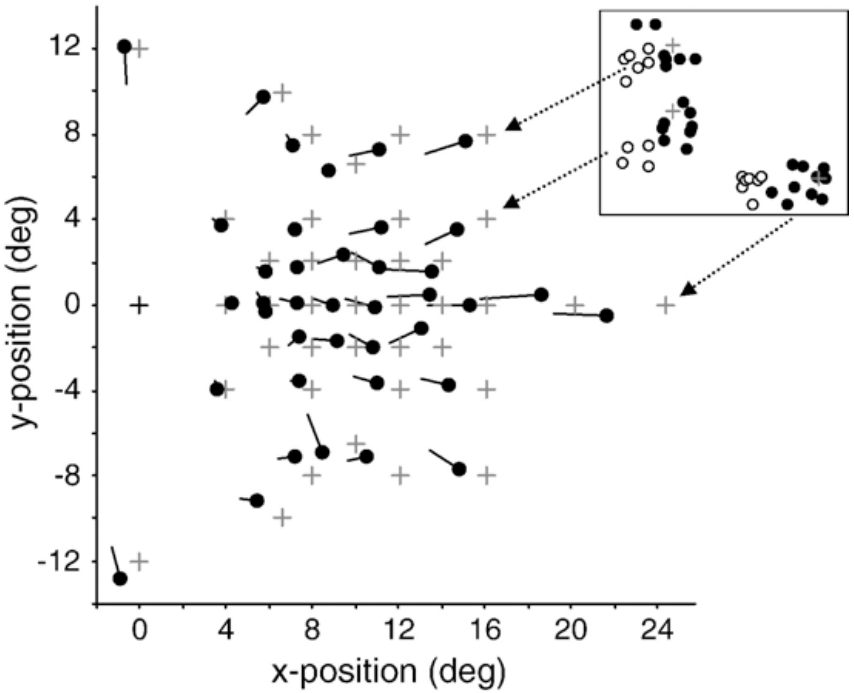
Procedure:

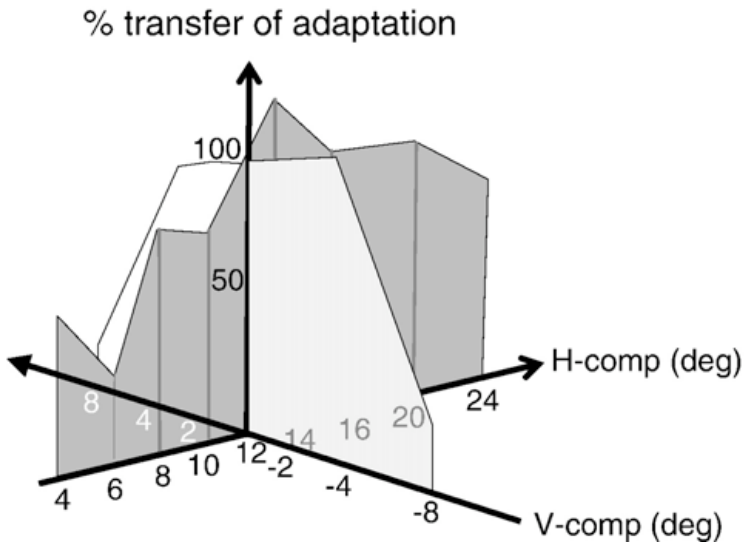


Adaptation:



Saccade endpoints after adaptation



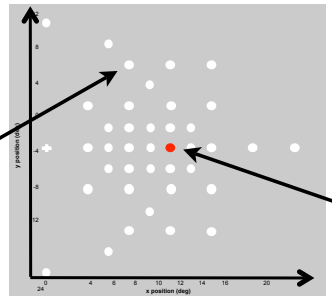


Localization results

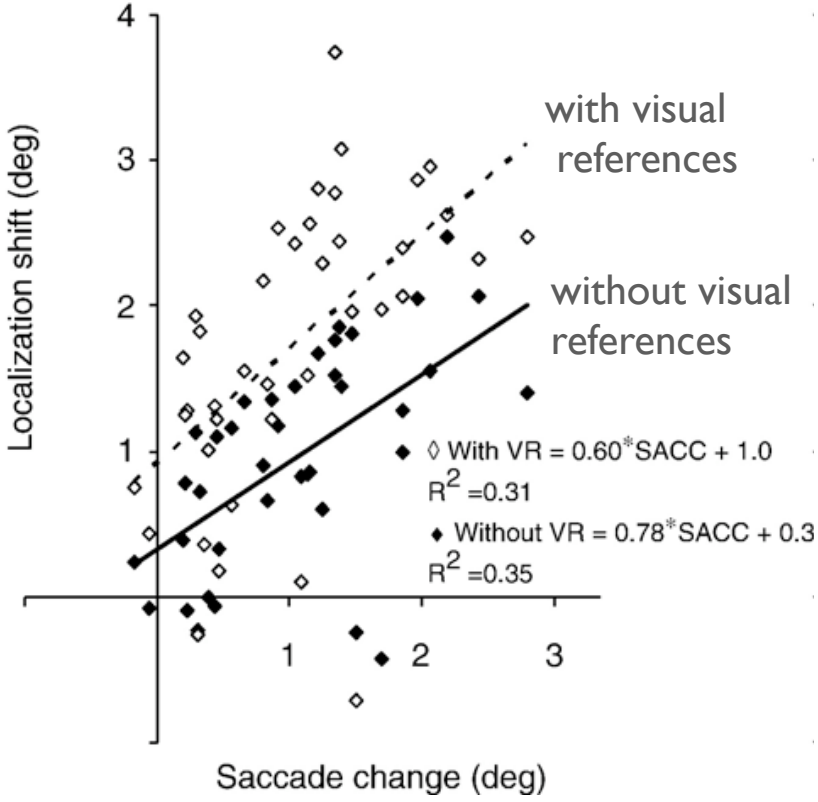
Bahcall & Kowler, Nature, 1999

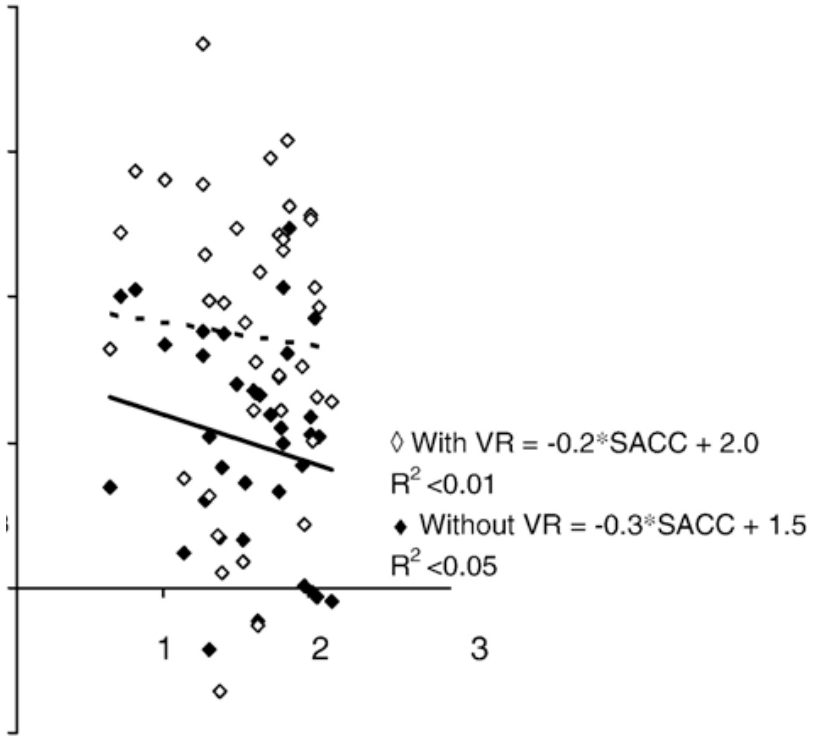
Correlation of localization with adaptation

Correlation with saccade to tested position:



Correlation with saccade to target:





The adaptation-induced shift

- Is related to the saccadic adaptation field
  - Without post-saccadic visual references, the localization is based on the metrics of the saccade that would be required to attain it
  - Localization is in alignment with post-saccadic visual references when they are available

How can saccadic adaptation
influence position judgements ?

Speculations on mechanisms

A. Eye position signal

B. Efference copy signal (adapted)

C. Efference copy signal (unadapted)

D. Post-saccadic visual references

E. Combination of references and efference copy

F. Adaptation of space

Speculations on mechanisms

A. Eye position signal

predicts no error at all because eye position always follows the true eye movement

Speculations on mechanisms

B. Efference copy signal (adapted)

predicts no errors at all because efference copy signal always follows the true eye movement

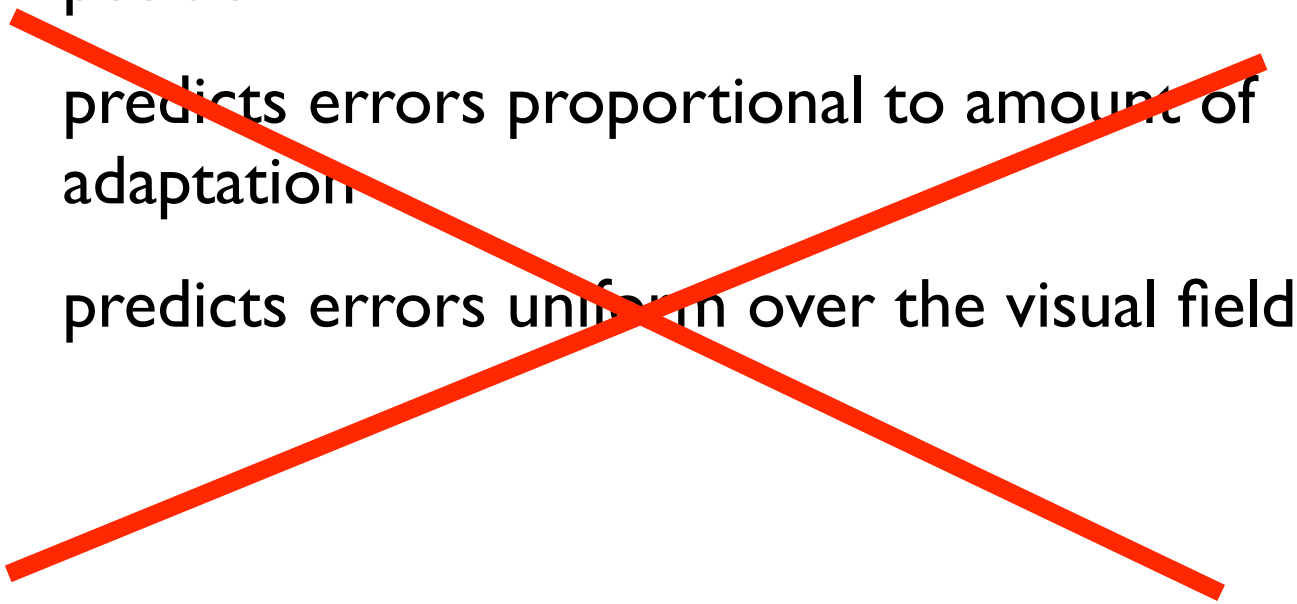
Speculations on mechanisms

C. Efference copy signal (unadapted)

predicts errors in adaptation direction because efference copy does not match the final eye position

predicts errors proportional to amount of adaptation

predicts errors uniform over the visual field



Speculations on mechanisms

D. Post-saccadic visual references

predicts errors in adaptation direction proportional to target back-step

predicts spatially uniform errors

no prediction when post-saccadic references are not available (as in no-step trials)

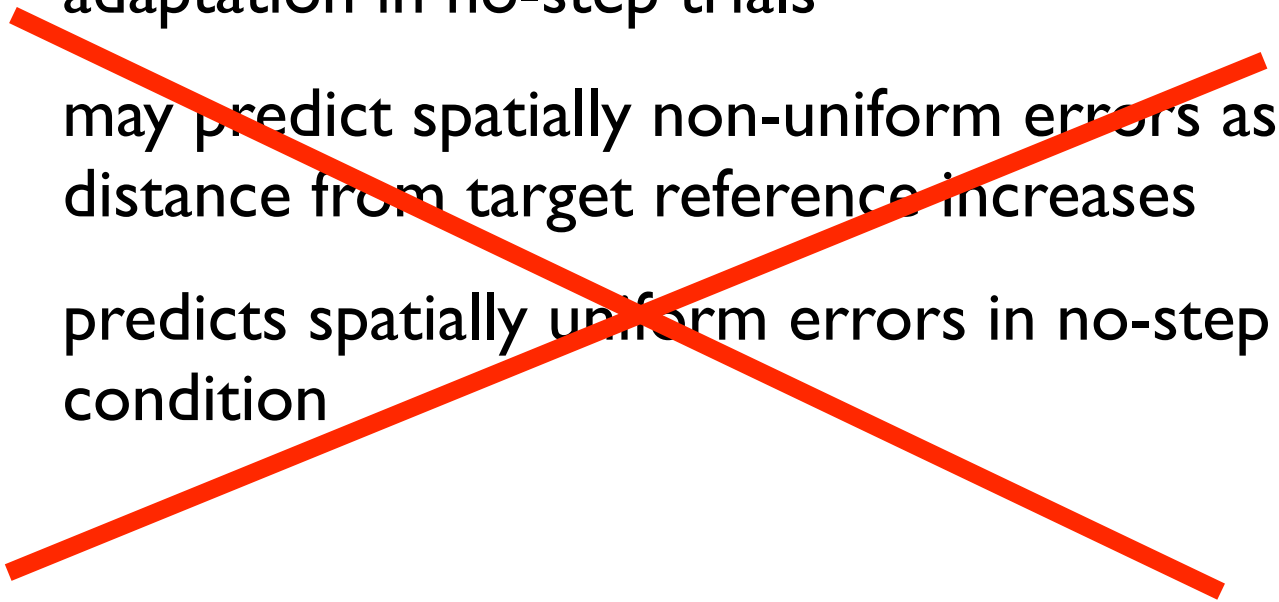
Speculations on mechanisms

E. Combination of references and efference copy

predicts errors proportional to target back-step with references and to amount of adaptation in no-step trials

may predict spatially non-uniform errors as distance from target reference increases

predicts spatially uniform errors in no-step condition



Speculations on mechanisms

A. Eye position signal

B. Efference copy signal (adapted)

C. Efference copy signal (unadapted)

D. Post-saccadic visual references

E. Combination of references and efference copy

F. Adaptation of space

Speculations on mechanisms

F. Adaptation of space

a. Adaptation in visual map

b. Adaptation of attention shifting

c. Space coding via saccade vectors

Speculations on mechanisms

F.a. Adaptation in visual map

predicts spatially non-uniform errors congruent with adaptation field

predicts errors also during fixation

appears inconsistent with physiology, common sense, and saccade adaptation literature

Speculations on mechanisms

F.b. Adaptation of attention shifting

predicts spatially non-uniform errors congruent with adaptation field

predicts errors also during fixation

appears inconsistent with physiology

Speculations on mechanisms

F.c. Space coding via saccade vectors

predicts spatially non-uniform errors congruent with adaptation field

no predictions for fixation

Objects are perceived at the location where a saccade towards the object would land

Current work

- Time course of shift during adaptation
- Re-evaluation of shift during fixation
- Reactive vs. scanning saccades

Planned work

- Model of adapatation and induced shift