Remapping, attention and localization
MacInnes, Hunt, 2014, EBR

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00000000 ms

Retinotopic coordinates

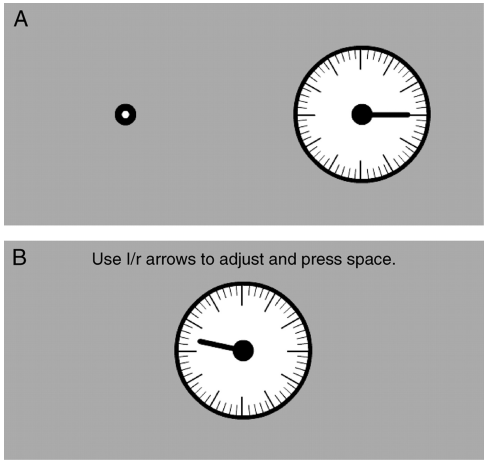
Spatiotopic coordinates

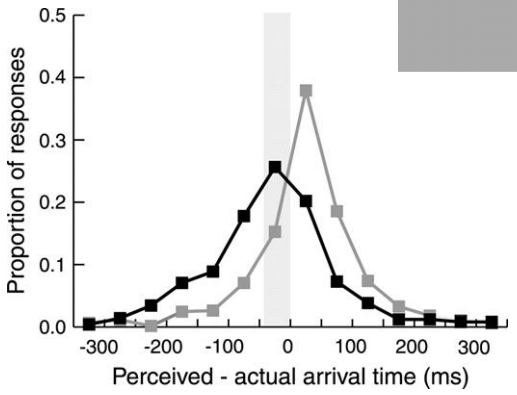
?

1. Object identity information
2. Object location information

Remapping I

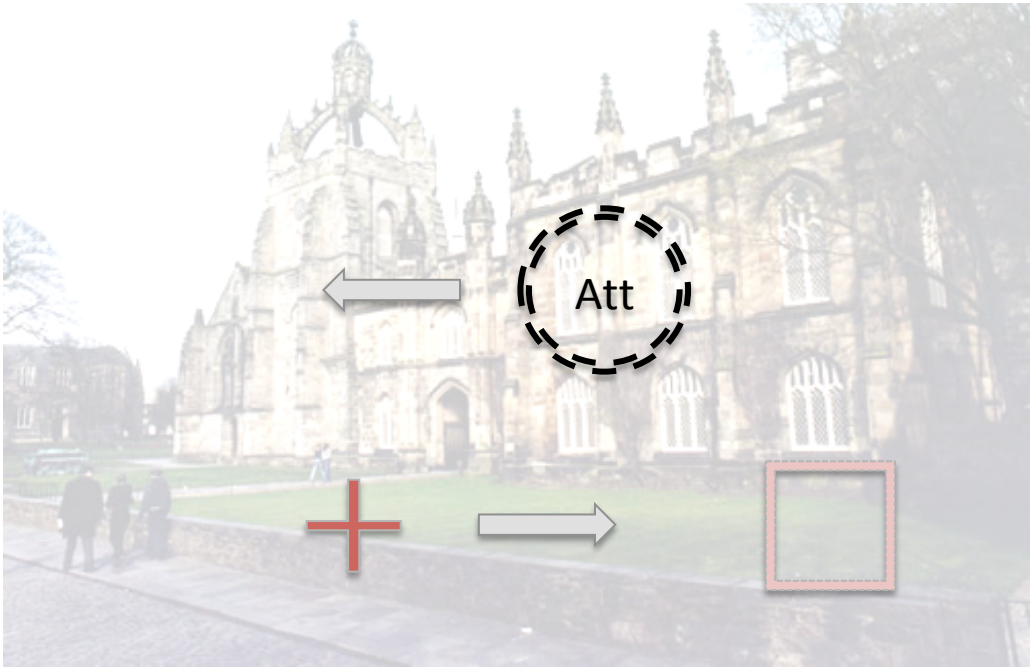
- Many visual neurons start firing to stimuli *before* it enters their receptive field
  - Striate(V1) and extrastriate (V3,4,5) cortex (Nakamura & Colby, 2002)
  - Lateral Interparietal cortex (LIP, Duhamel, Colby, & Goldberg, 1992)
  - Frontal Eye Fields (FEF, Sommer & Wurtz, 2002, 2006)
- If a saccade is about to bring that stimuli into the receptive field
- Eg, saccade location receives high precision before the eye arrives



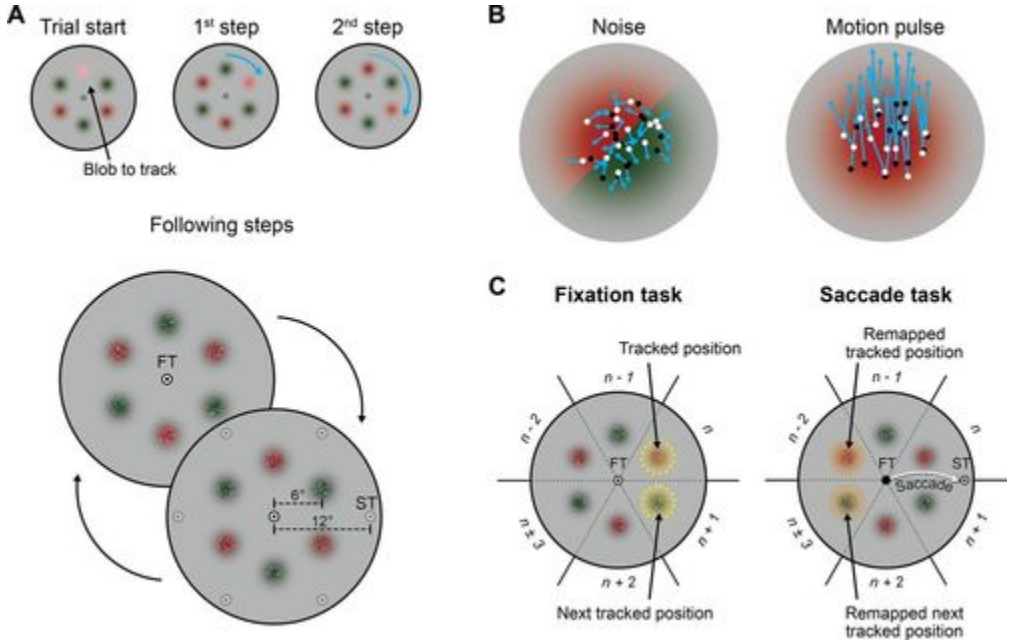


Remapping II : secondary attended locations

- LIP contains a retinotopic map, with activity peaks at attended locations
- Remapping is the pre-saccadic activation for cells for which the location of an attended stimulus *will be* after the saccade (Duhamel etal, 1992)
  - Observed in Lateral Intraparietal (LIP) and Frontal Eye Fields (FEF) among others
  - But only if location is attended Gottlieb, Kusinoki & Goldberg, 1998)



- Szinte et al


A
Trial start
1st step
2nd step
Blob to track
Following steps
FT
6°
12°
ST
B
Noise
Motion pulse
C
Fixation task
Saccade task
Tracked position
Remapped tracked position
n - 1
n - 2
n + 3
n + 1
n + 2
FT
ST
Saccade
Next tracked position
Remapped next tracked position

Corollary discharge

- Corollary discharge is a copy of motor signal sent to perceptual areas.
  - Sperry, 1950; von Holst and Mittelstaedt, 1950
- Often arrives before the actual movement
  - Eg saccade
- Likely an important mechanism involved in remapping since it would provide an estimate of the result of that future movement
- Remapping makes a presaccadic prediction of what a neuron will 'see' after the saccade
  - an 'ideal' system would simply compare the results of the prediction to the actual saccadic results
  - The human visual system is not ideal, as seen with Saccadic suppression of displacement (read Deubel – or ask Daria)

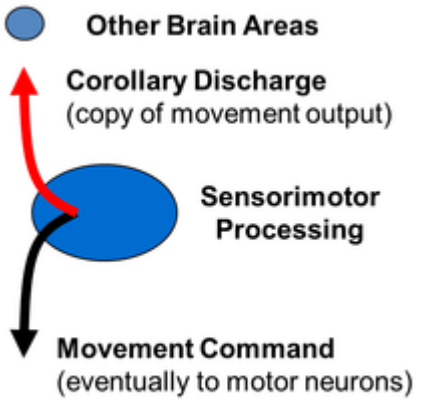


Figure 1

Fields or attention

- Remapping has been suggested as a mechanism which supplies stability across saccades (Wurtz, 2008) by remapping locations of interest to a new retinotopic location
  - By Shifting a cell's actual **receptive field** (Sommer and Wurtz)
  - By shifting localized **attentional** pointers. (Cavanagh etal 2010; Hunt and Cavanagh, 2011)
- Rather than a spatiotopic map of the world (think like the Itti & Koch model), we have a Retinotopic map that is updated with the corollary discharge
- We know that objects in the world must be attended to be remapped
  - Therefor limited # of objects

CD → remapping → stability

Retinotopy/Spatiotopy

- Conflicting reports with FMRI + eyetracking to determine contribution of spatio and retino maps

- Spatiotopy
  - MT, D'Avossa et al., 2007
  - LOC, McKyton and Zohary, 2007

- Retinotopy
  - MT and LOC ,Gardner, Merriam, Movshon and Heeger, 2008; Golomb and Kanwisher, 2012

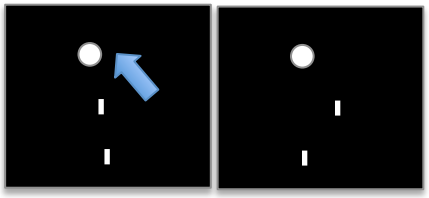
- Spatio when attention free
  - MT: Crespi, Biagi, d'Avossa, Burr, Tosetti et al. (2011)
  - But see Golomb and Kanwisher (2012)

Hypotheses

- E1: Under conditions of high attentional load, the ability to remap will be diminished
  - Manipulate load – Vernier Acuity stream detection task (Berry, 1948, Sullivan 1972…)

- E2: Under a high load condition we will see a higher reliance on any available environmental landmarks
  - Gaze contingent landmark

or

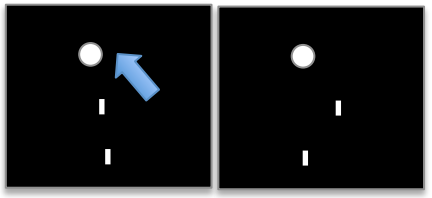


Dual task:
1) Localization
2)Easy or difficult vernier acuity detection stream

Methods

- We explored remapping as measured by a localization task with an intervening saccade
- We also manipulated attentional load in secondary task: a vernier stream detection task
- DV is Euclidean error in localization
- IV
  - saccade vs no saccade
  - High vs low load
  - (E2) stable vs shifting landmarks

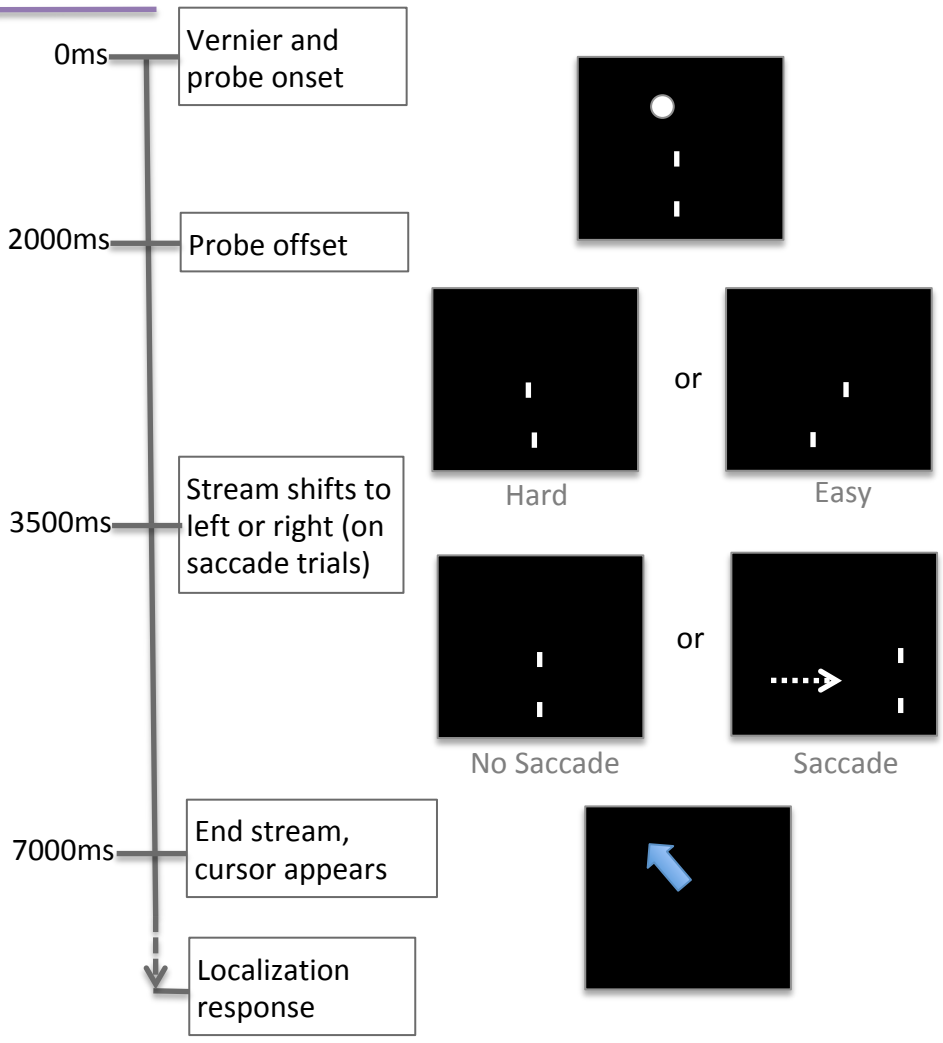
or



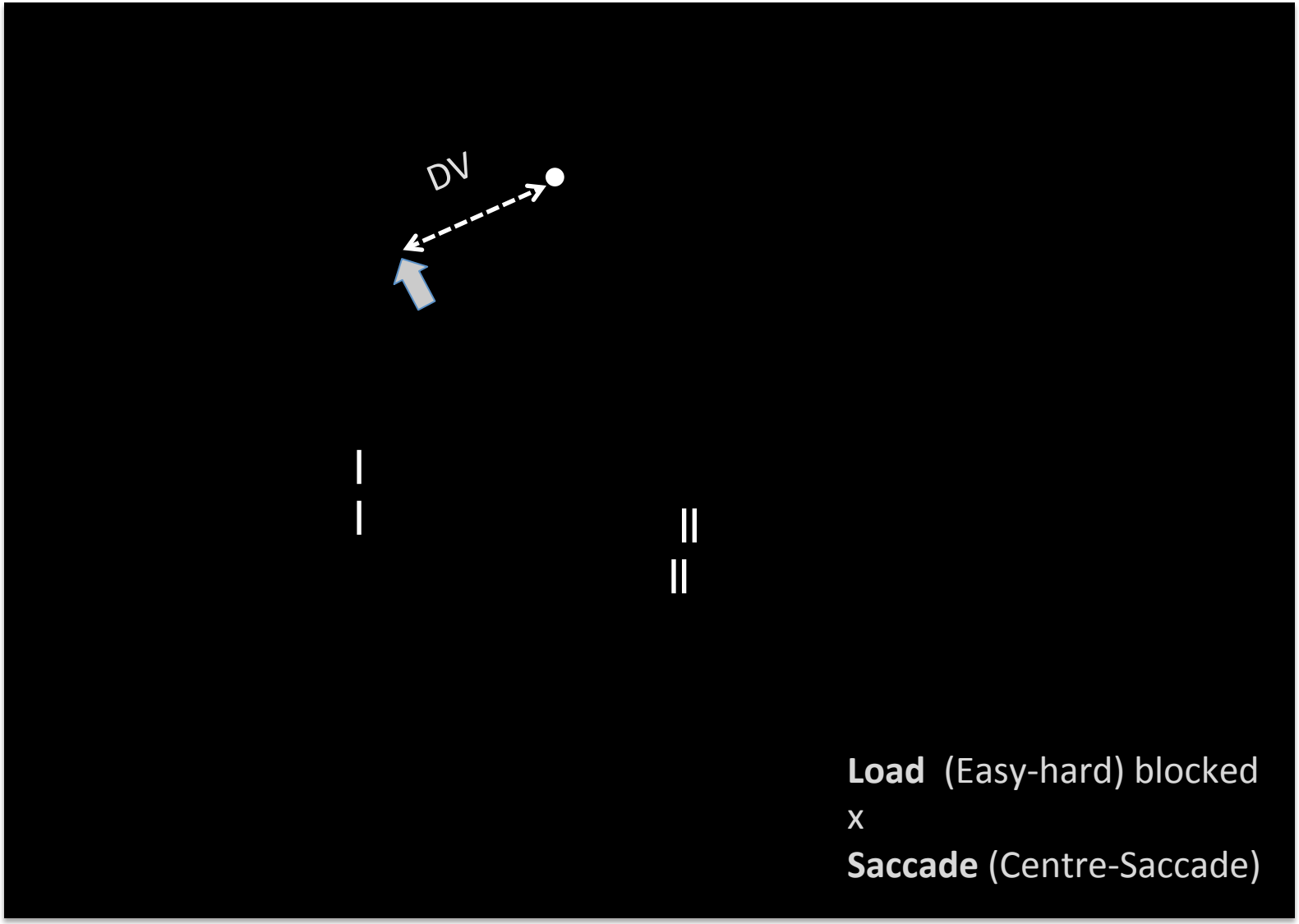
Dual task:
1) Localization
2)Easy or difficult vernier acuity detection stream

E1 methods

- Dark room, dark adapted
- Special OLED black screen
- No eye tracking due to dark room requirements

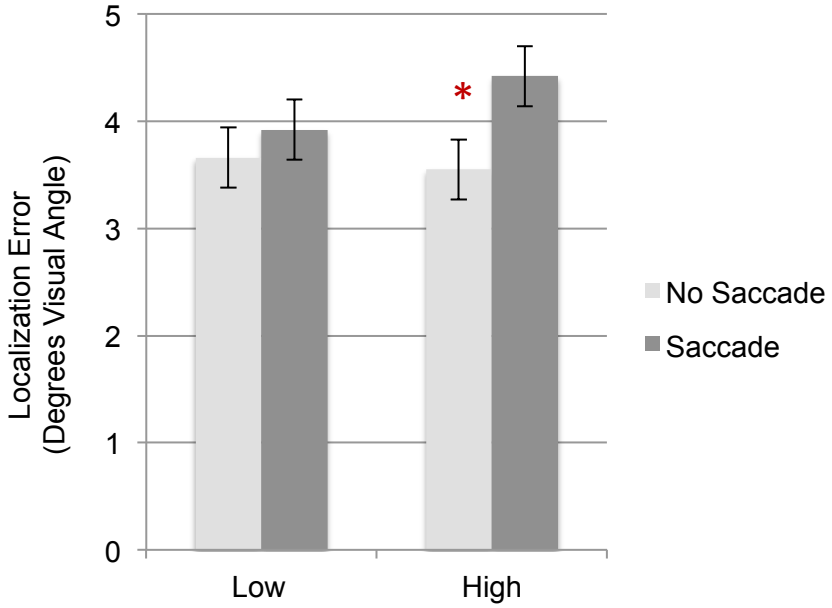


E1 : No Landmarks



E1: Saccade x Load

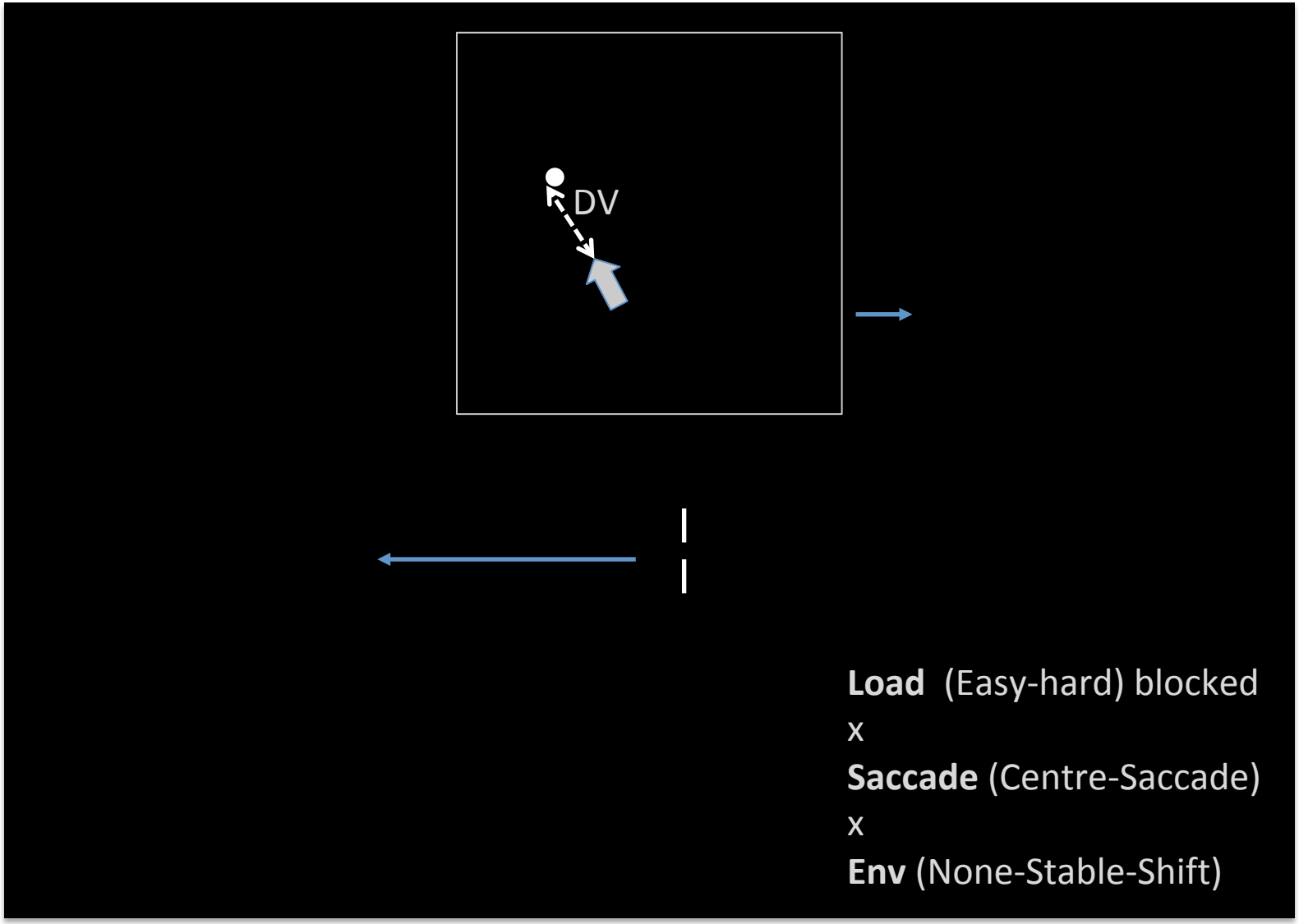
- Effect of saccade
  - Greater localization error during saccade trials
- Saccade x Load interaction
  - Increased error in Saccade condition only
  - Sufficient attention in Low load condition for remapping



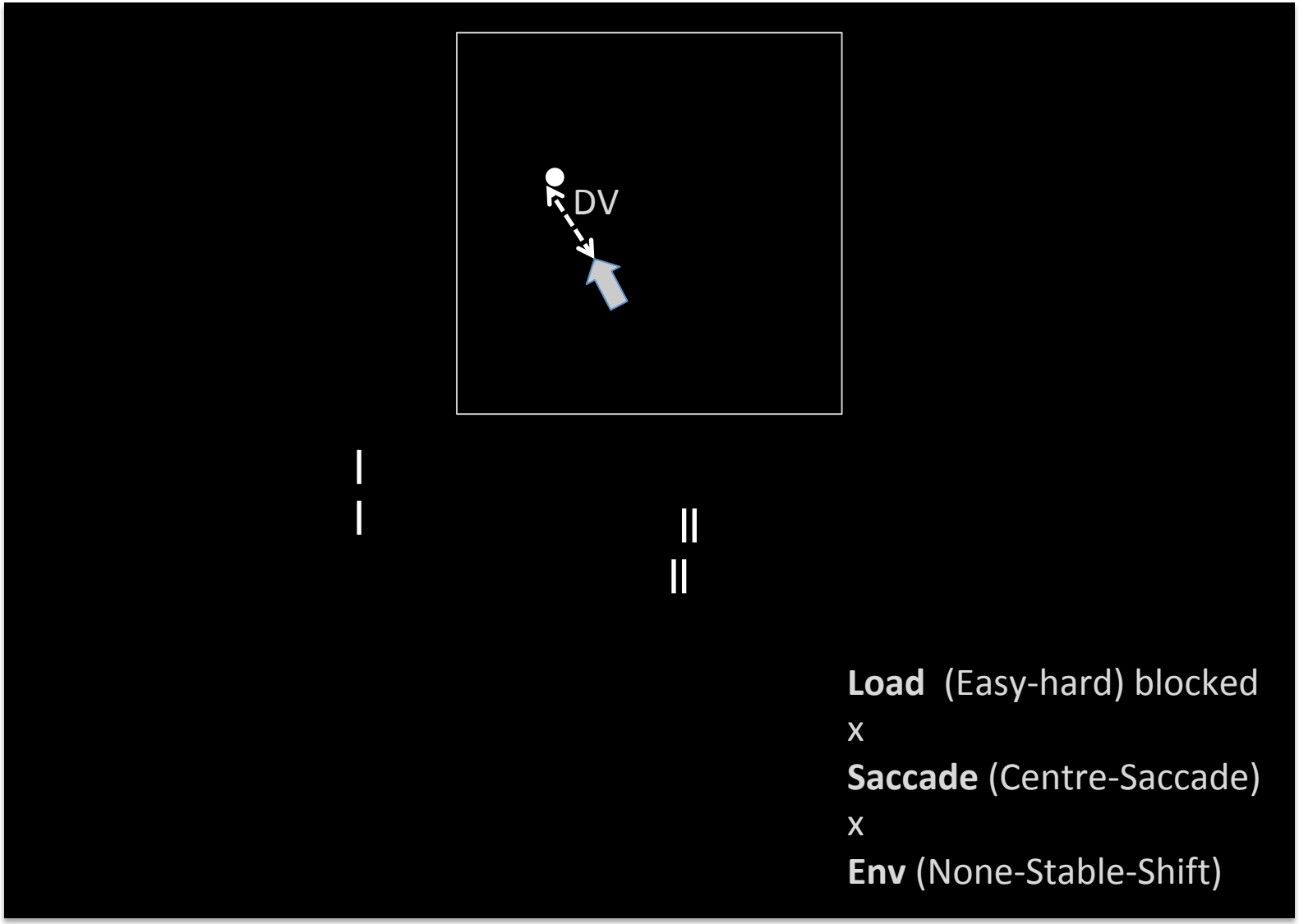
E2: Predictions

- Landmark free environments are unlikely in nature
- Environmental landmark, when present, will aid localization
- Introducing eye tracking will likely add other visible landmarks
  - We need to introduce an extremely salient landmark for them to use
- Participants will rely on this landmark more in high load conditions to compensate for load on remapping
  - Shifting that environmental landmark during a saccade will therefore have a larger localization cost in high load conditions than in low load condition (E2)

E2 : Unstable **gaze contingent** landmark

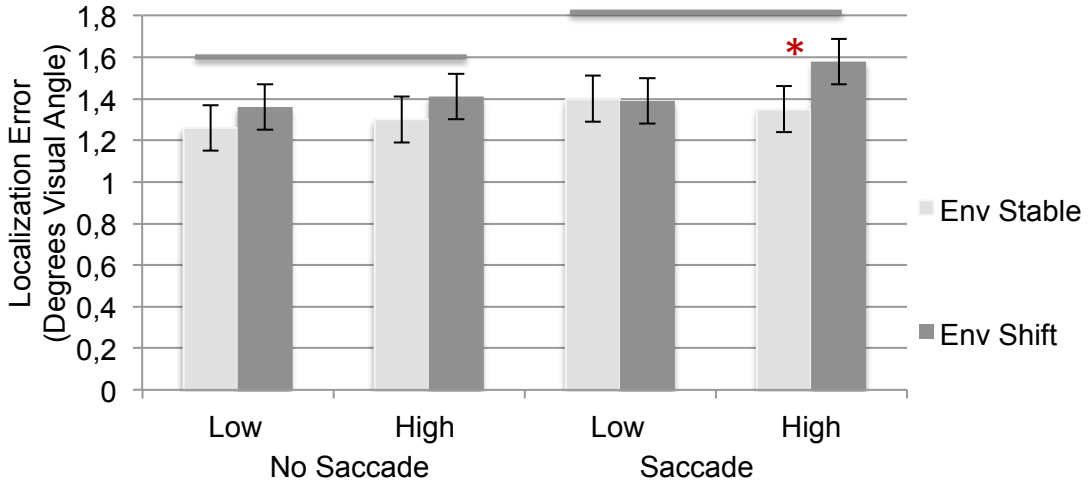


E2 : Unstable gaze contingent landmark



E1: Saccade x shift x load

- Main effects of Environment and Saccade
- Expected 3-way interaction
- Load manipulation only punitive during environment shifts coinciding with saccade
- Interaction suggests role of attention in remapping coordinates

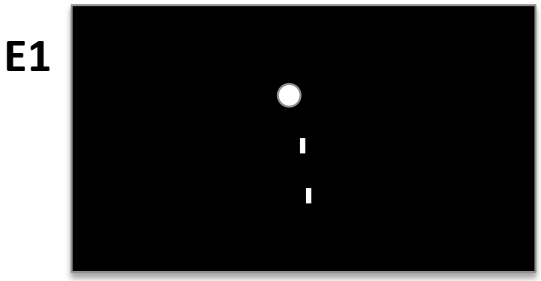


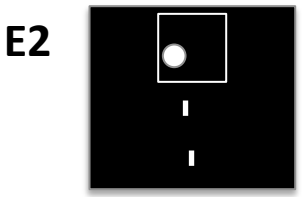
Conclusions

- Landmarks aid localization when available
  - Even under attentional load
- Visual system is capable of multiple localization strategies across saccades
  - Retinotopic/remapped
  - Spatiotopic/landmark
- Loading attention reduces accuracy of retinotopic strategy (E1) and forces greater reliance on spatial strategy (E2)
- Future work:
  - More direct link between remapping and localization
  - Timing of attention allocation

Other Strategies

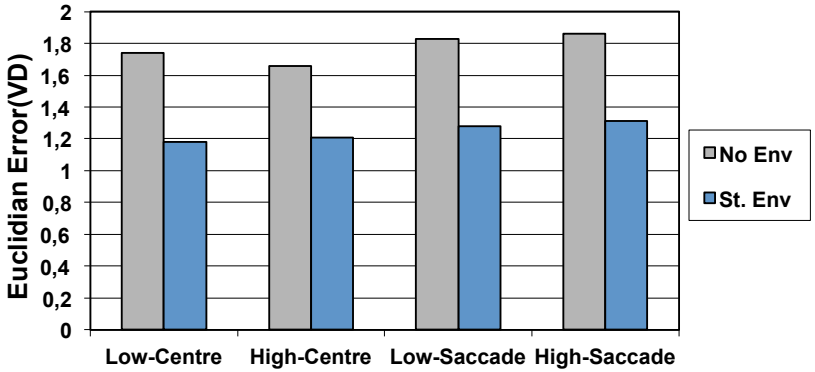
- What of other localization strategies?
- Saccade back to centre before localization?
  - We staggered centre and L/R stream locations (E1, E2)
- Environment coordinates like the monitor's edge?
  - E1: OLED screen
    - Dark adopted, no landmarks
    - (Saccade x Load)
  - E2: Provide explicit environment marker which we shift in mid saccade
    - (Saccade x Load x Environment)
  - S's should be more hindered by that shift in high load condition
- Load manipulation blocked





E2: Environment Benefit

- Participants are able to make use of stable environment cue across all conditions



Main effect of Environment(F=110; P<.001)

Trend of saccade (F=2.8; P<.10)

- Questions?

Related lit someone might bring up

- Deubel landmarks, 2002
- Koch and Deubel, 2007. landmarks using centre of gravity
  - As evidence against stable world? Landmarks used that were not there pre saccade?
  - Higgens and wang, 2010 use of flanking landmarks
- Blanking improves detection of form changes, deubel, 2002
  - Assumption of stability underlies both types of change detection?
- Form information factored into transaccadic update
  - McConkie & Currie, 1996
- Neimier 2003 bayesian model of stability. Predicts 'graded apparent displacement effects'
- Masking effect suggested by De Graef and Verfaillie (2002)
  - 'Visual analogue' is high res image available at each fixation, but degrades 100+ms and subject to masking from next fixation
  - Also Germeys, De Graef, Van Eccelpoel, and Verfaillie 201?

Neimeir, 2003

- Model input from three noisy sources
  - source is the retinal locations of images, but retinal acuity declines with eccentricity
  - velocity signals from visual motion detectors; these are accurate when the eyes are Stationary , but ineffective during saccades
  - sense of eye position, derived from muscle spindles or motor commands , but this information is also imperfectly reliable, especially during saccades

- .
- ‘SSD need not reflect flawed transsaccadic integration, but is an unavoidable consequence of optimal inference from imperfect signals.’
- Demayer seems to agree with this, in that any disruption of assumption of stability reduces noise?