PLAsticiTY of Perceptual space Under Sensorimotor interactions

European Commission

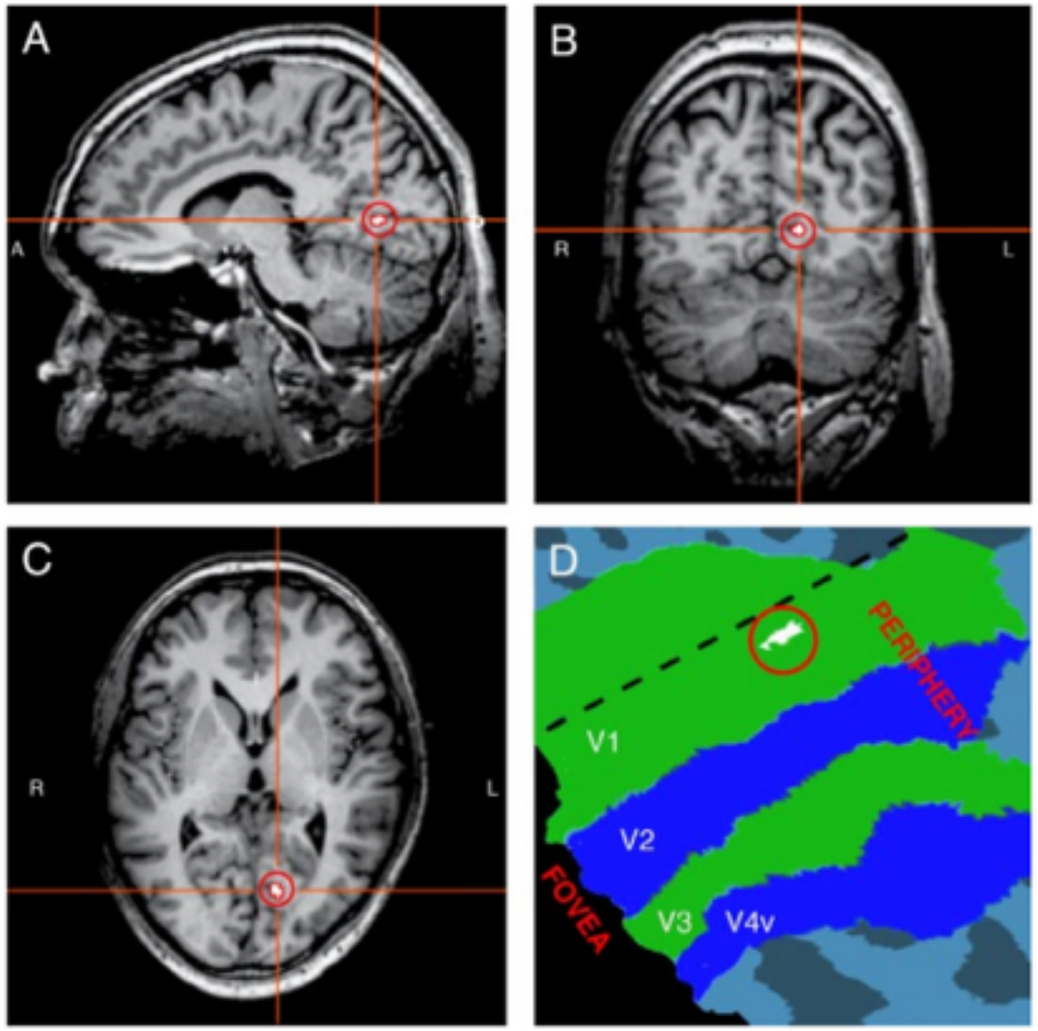
Research and Innovation Staff Exchange (RISE) Call: H2020-MSCA-RISE-2016

A gap in the map: the blind spot

Task 2.1

Neurophysiological findings

- Blind spot has a representation in V1 *(monkey: Azzi et al. 2015; human: Awater et al., 2005, Tong and Engel, 2001, Tootell et al., 1998),* i.e. there are receptive fields in the V1 map that represent the space of the blind spot in the retinal image (answer more strongly to the fellow eye than to presentation in the blindspot eye)



Representation of blind spot in V1 figure from Awater et al. (2005)

Neurophysiological findings

Discontinuos RF that specifically respond to stimulation of opposing edges *(Fiorani, 1992)*

Cells in deep layers of V1 respond to large uniform patch covering BS. Large receptive fields that extent outside the Blindspot region. *(Komatsu et al, 2000)*

Neurons in deep layers of V1 (layer 6) respond to large stimuli, have very large receptive fields and induce filling in. *(Komatsu et al, 2002)*

Monkey were presented with bars that crossed the blindspot. When bars were visible at both sides of the blind spot, filling-in occured and the size of the bar was estimated much longer. Response latencies in V1 to stimuli in blind spot eye are 12 ms slower than to the fellow eye. Indicates long horizontal connections that feedforward to V2 which then feeds backward to V1. *(Matsumoto and Komatsu, 2005)*

Neurophysiological findings

- Single and multi-electrode measurement of monkey V1
- 2 tasks, local and global mapping
- global mapping induced activity inside the BS region
  - RF inside BS were larger than outside but organized topographically similar
  - orientation or direction tuning were comparable to V1 regions outside of BS

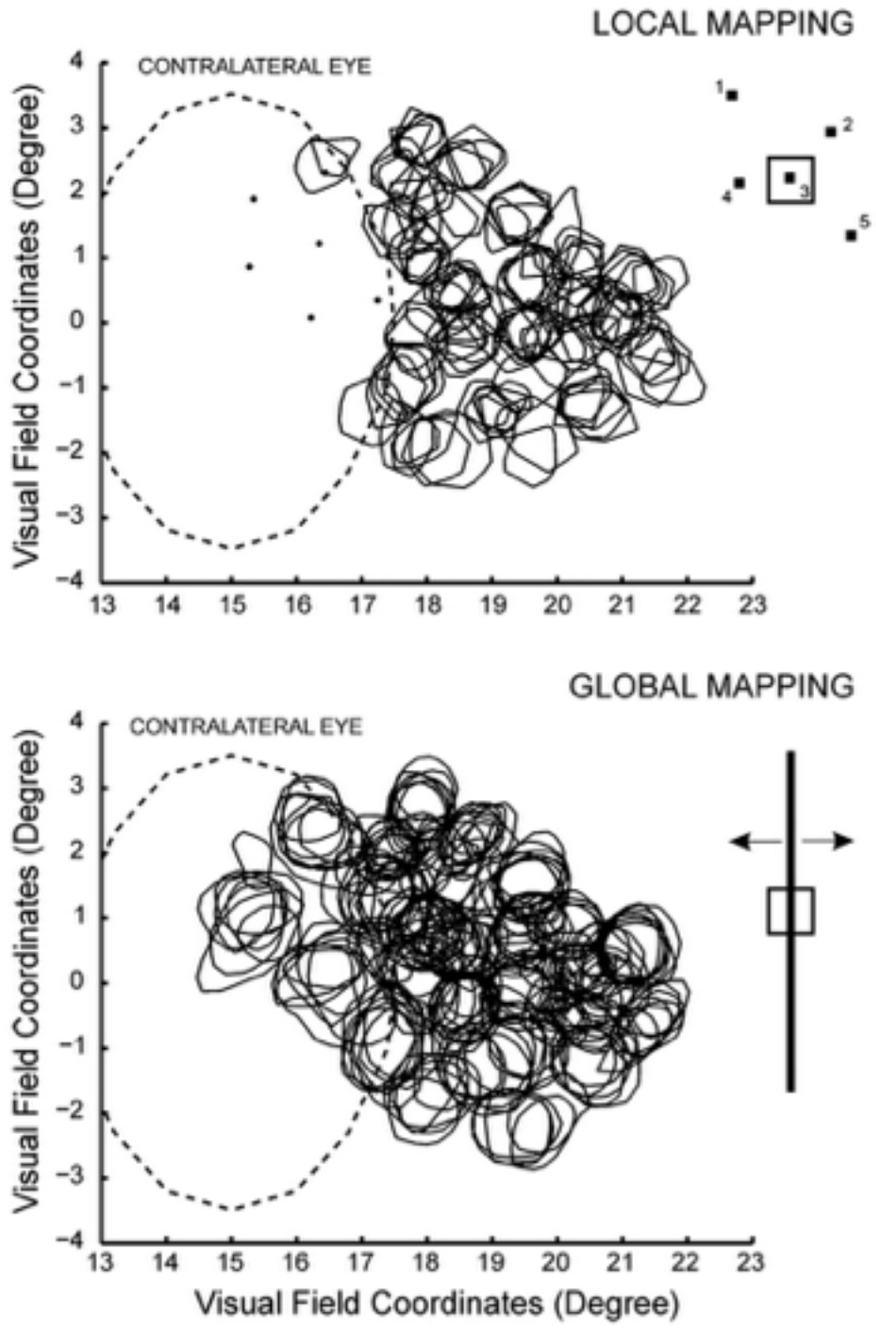
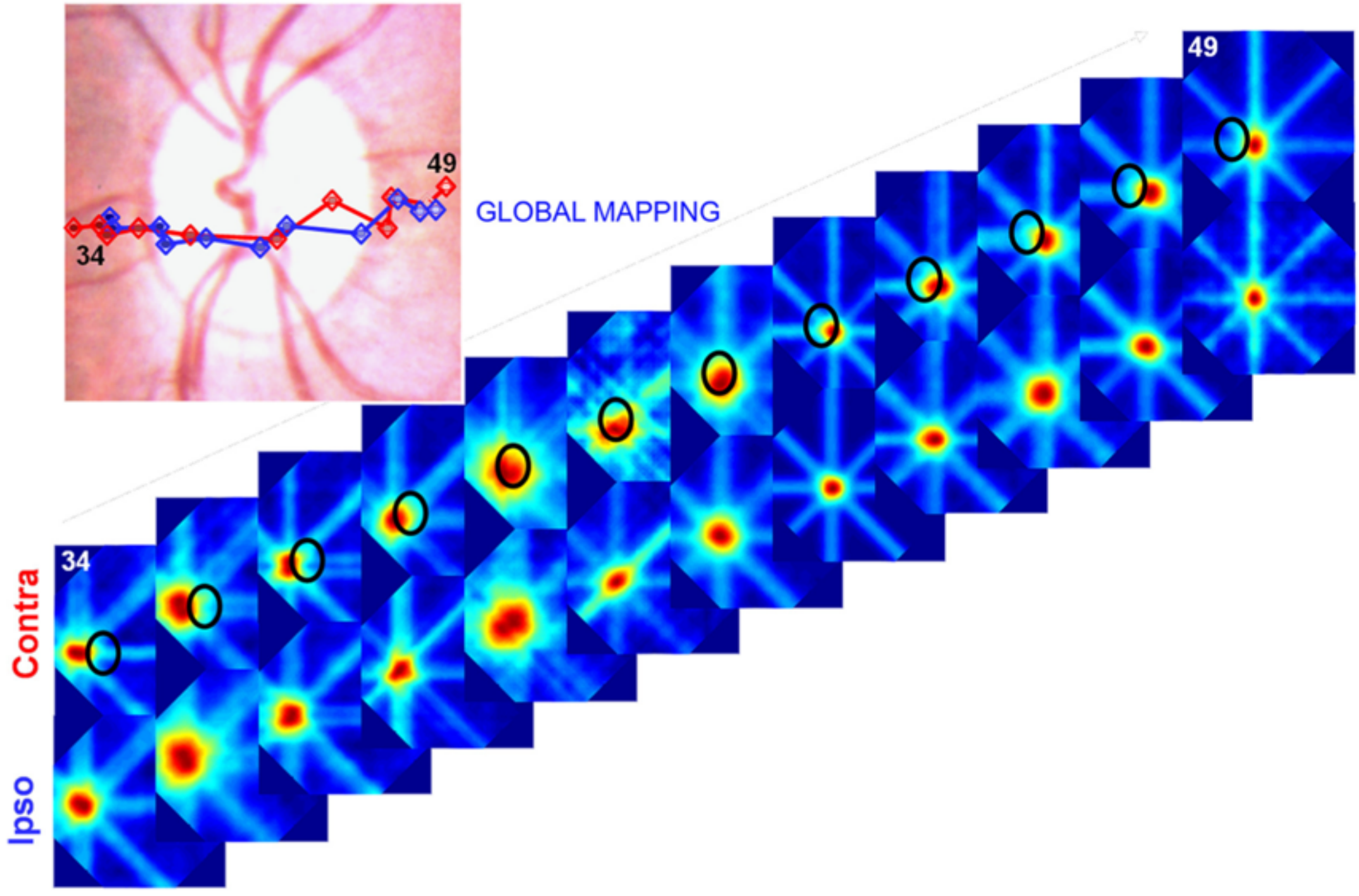


figure from Azzi et al. (2015)

Azzi et al. (2015)



Characteristics of the blind spot

- passive filling vs active completion
- Visual field is not distorted around the blind spot *(Tripathy et al., 1996; Awater et al., 2005)*
- Filling-in can occur starting from frames that are .06 deg wide. For patterns minimum is .3 deg width for (partial) filling in (Spillmann et al., 2006)

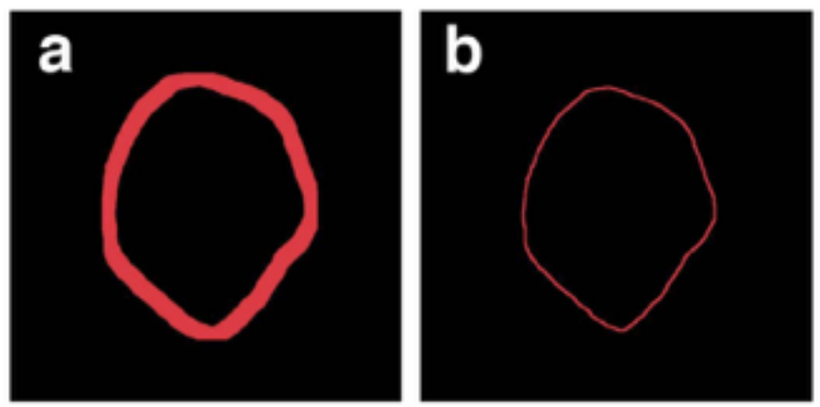


figure from Spillmann et al. (2006)

Filling-in of stimuli at BS

- Items that can fill-in
  - lines (dot patterns) *(Araragi et al., 2011, Baek et al., 2012)*
  - colors *(Li et al., 2014)*
  - patterns, surfaces (amodal completion)*(Durgin, 1995)*
  - movement throughout blind spot continuos starting at 30 deg/sec *(Tripathy, 2006)*

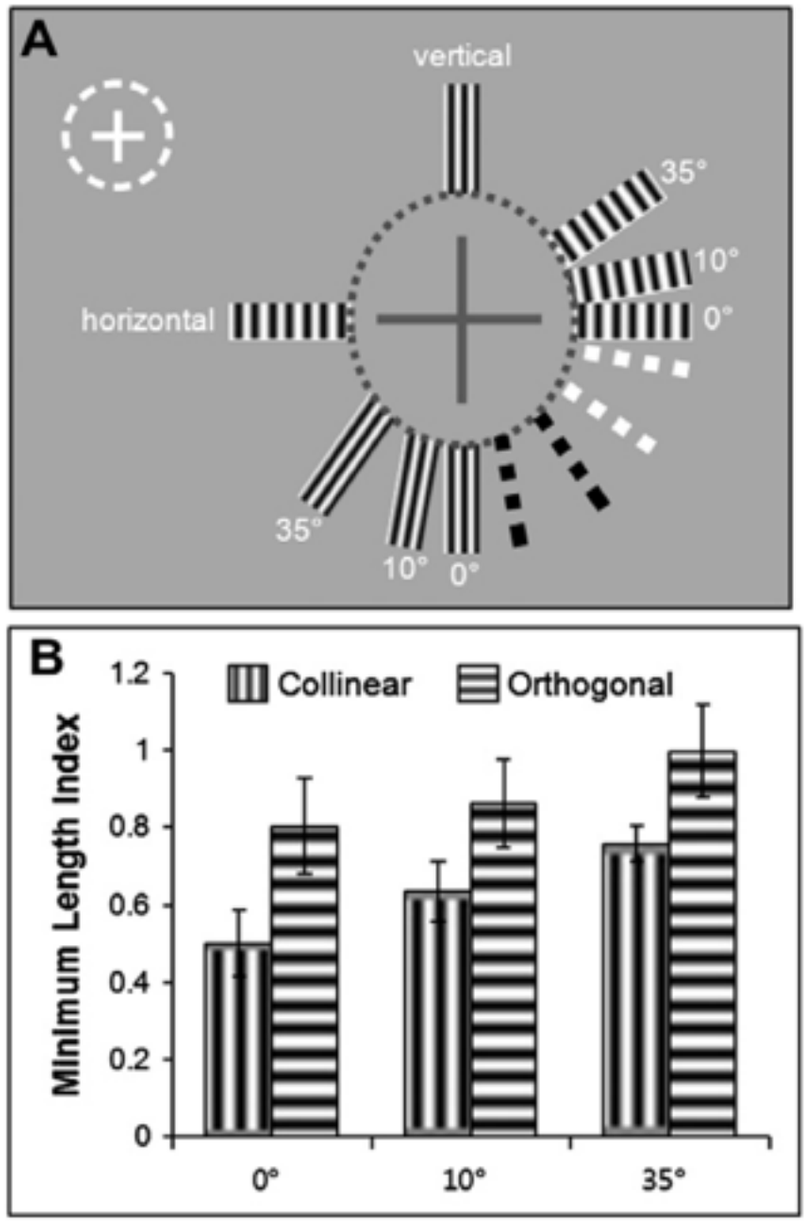


figure from Baek et al. (2012)

Filling-in of color

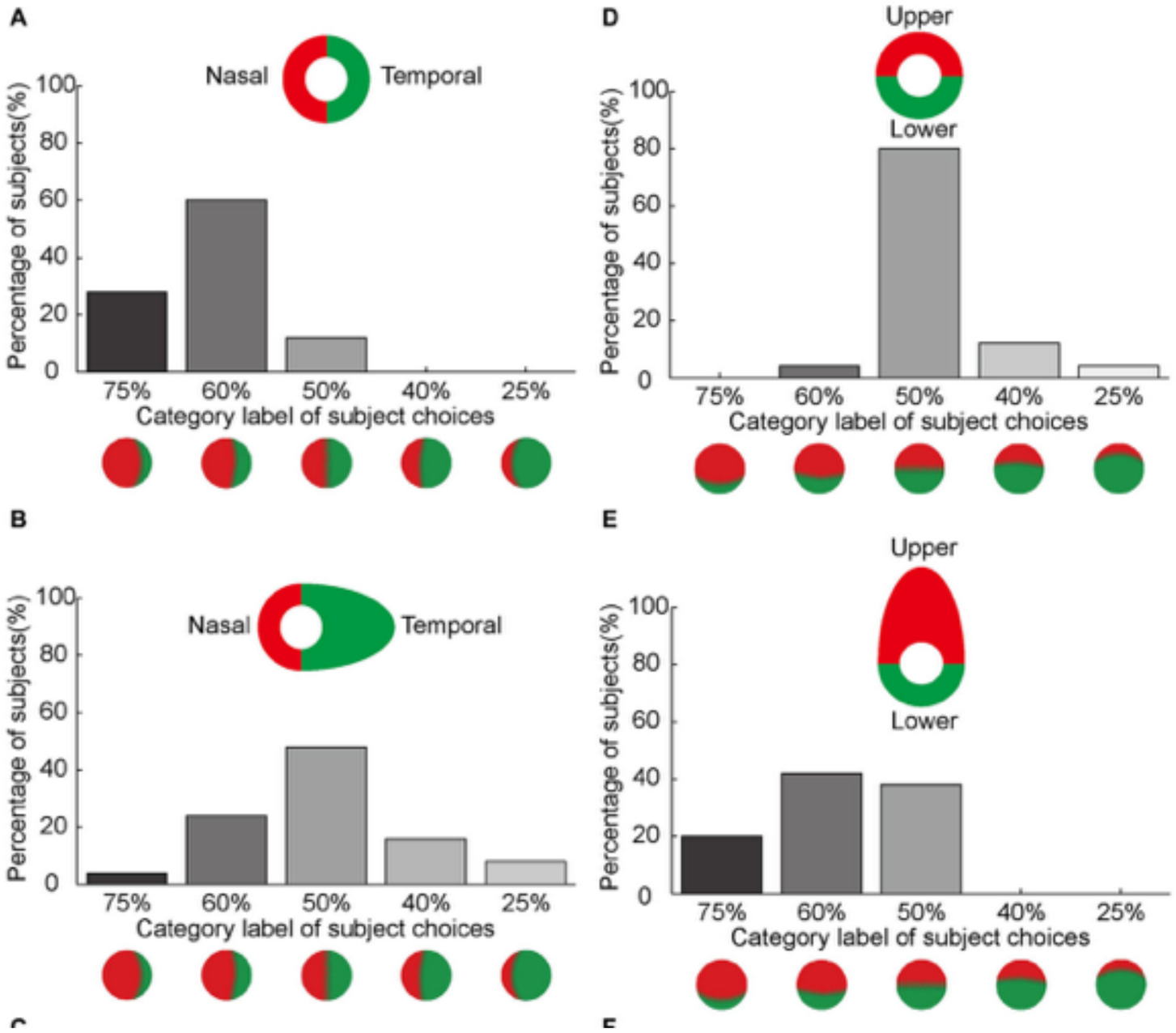


figure from Li et al. (2014)

Filling-in of lines

- requirements for filling-in of a line at the blindspot *(Araragi et al., 2011)*
  - facing-requirement
  - minimal length for filling in of bar .2 deg
  - similarity of facing stimuli (offset, angle, luminance)
- blindspot awareness comes before blindspot filling in *(Abadi et al., 2011)*

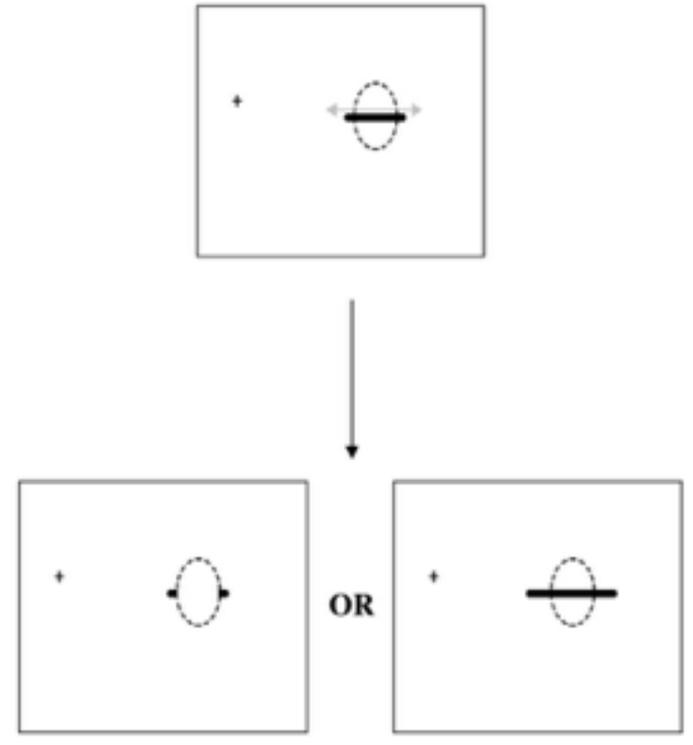
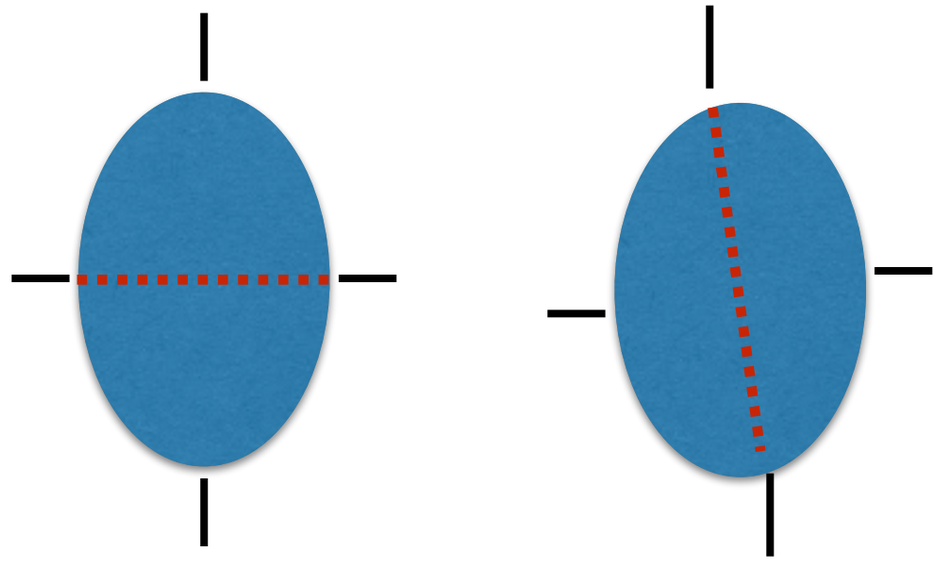


figure from (Abadi et al., 2011)

Filling in of Lines

- anisotropy of the the blindspot line-completion:
  - horizontally shorter bars trigger completion, vertically a greater disparity between lines is tolerated *(Araragi et al., 2004, 2011)*



- Behaviour can be replicated by application of a hierarchical predictive coding model that has learned natural statistics *(Raman and Sakar, 2016, Raman and Sakar, 2017)*

Characteristics of the filled in percept

- Filled-in percept can induce rivalry *(Tong & Engel, 2001, Quian et al., 2017, Chen et al., 2017)* and even depth percept *(Chen et al., 2018)*

- Motion, moving dot/ drifting bar can be extrapolated into the blind spot *(Maus et al., 2008, Maus et al., 2016)*

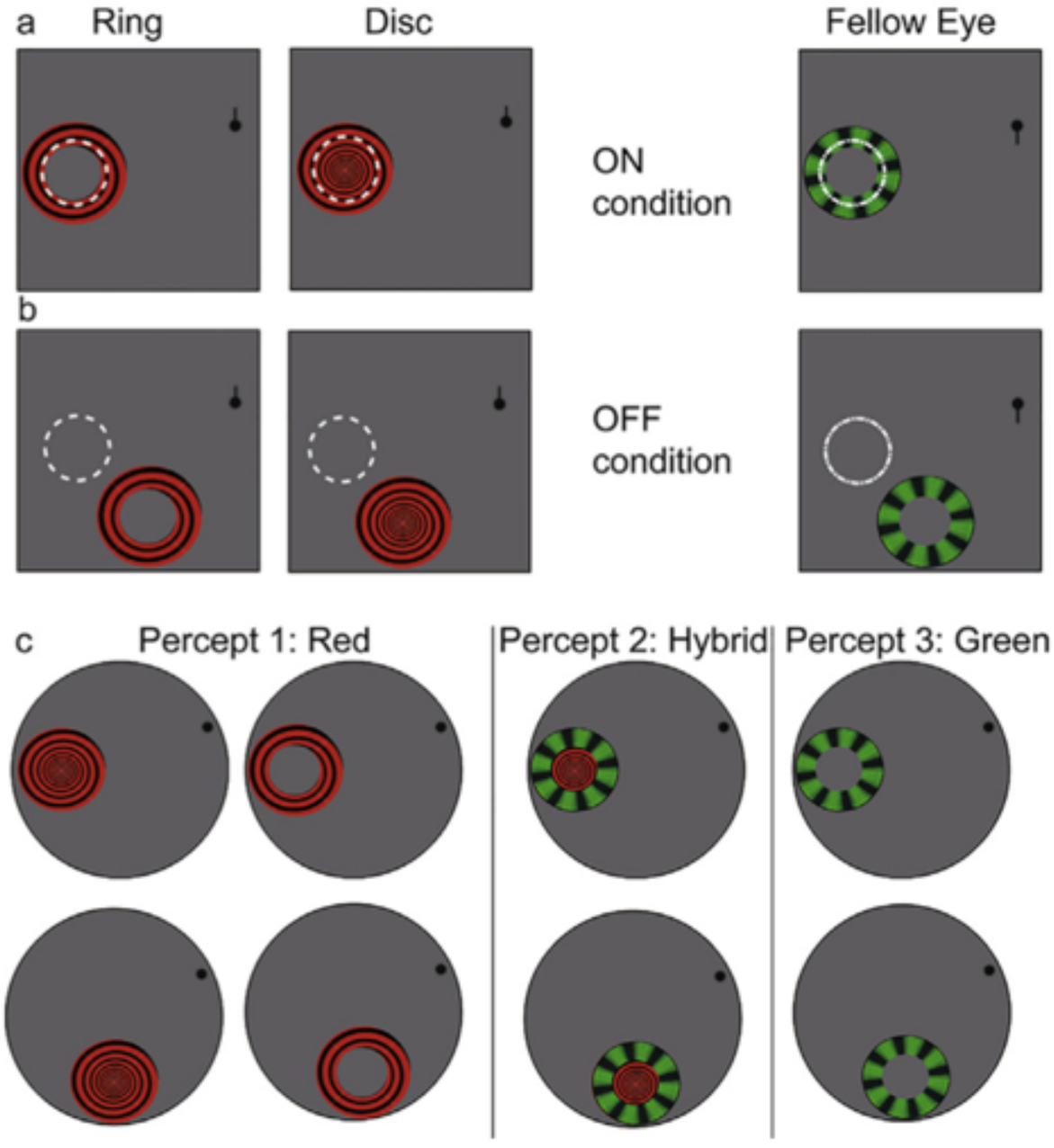
- filling-in generates after image *(Shimojo, 2001)*

- No saccadic preference for blind spot *(König, 2016)*

Binocular rivalry

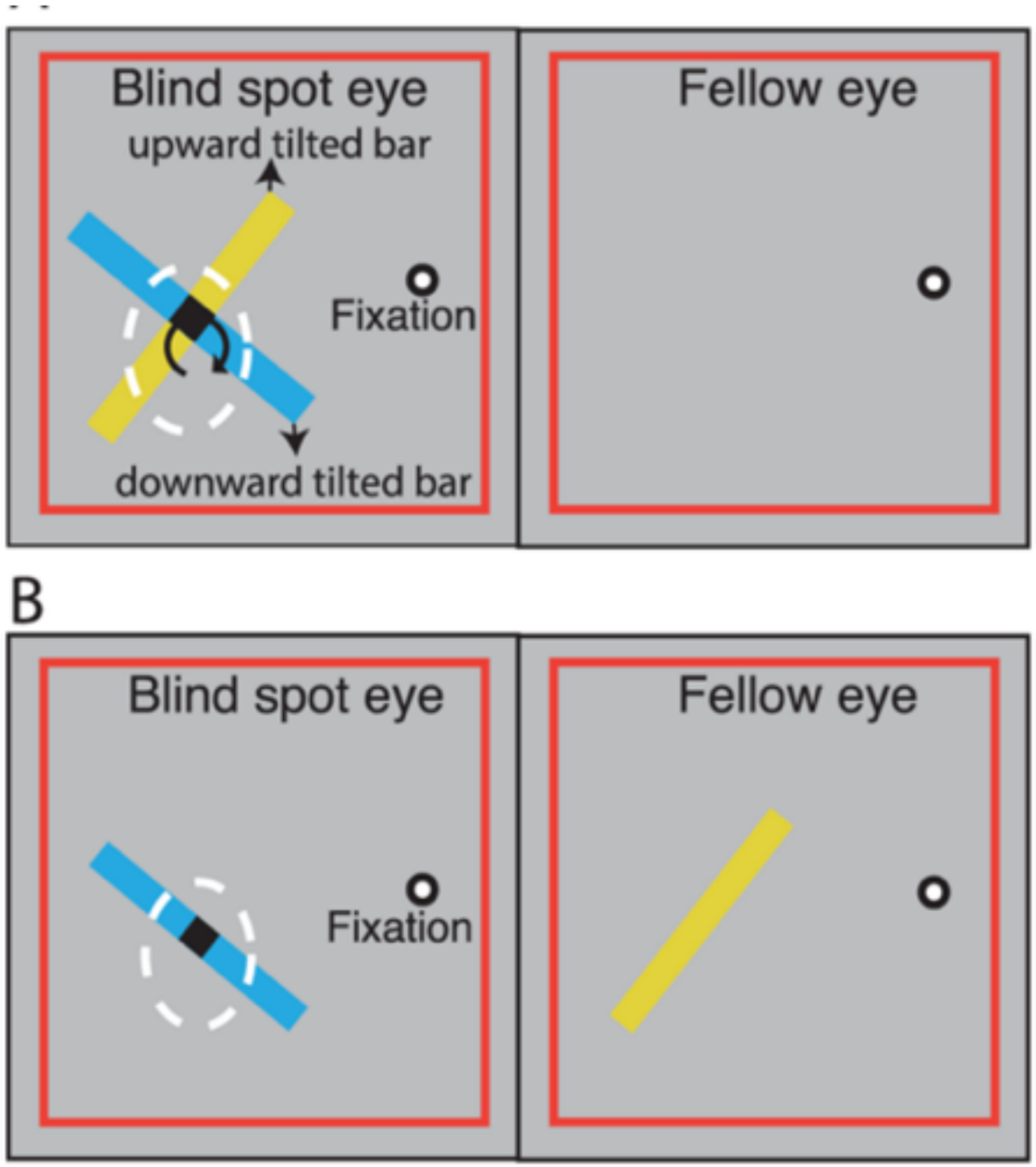
- Binocular rivalry happens before Filling-In at the Blind Spot *(Quian et al. 2017)*

- Early stages of visual system resolve binocular rivalry issues



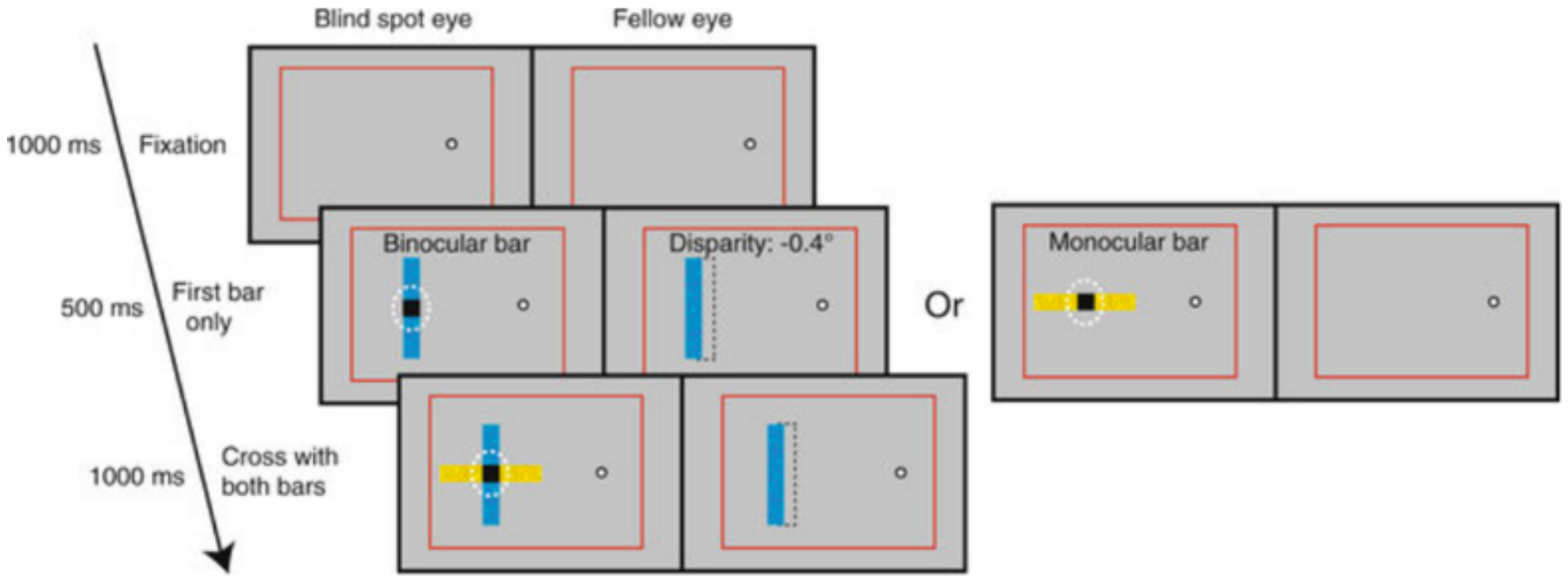
Monocular rivalry

- Filling-in rivalry: Perceptual alternations in the absence of retinal image conflict *(Chen et al., 2017)*

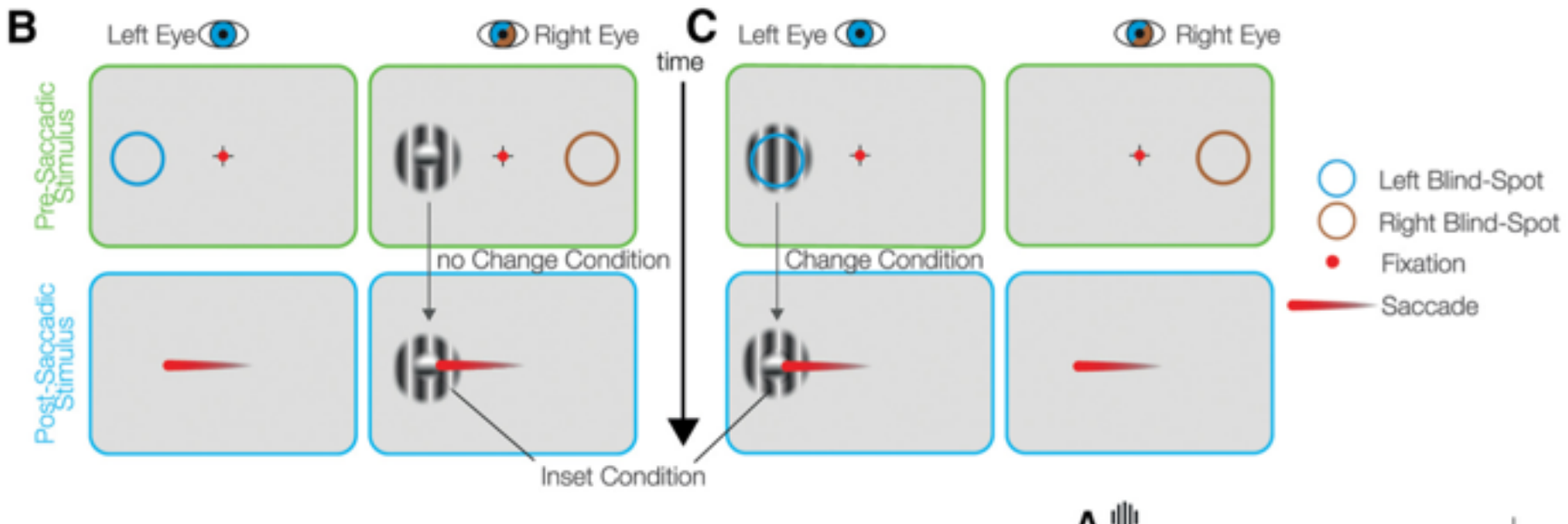


Percept in depth

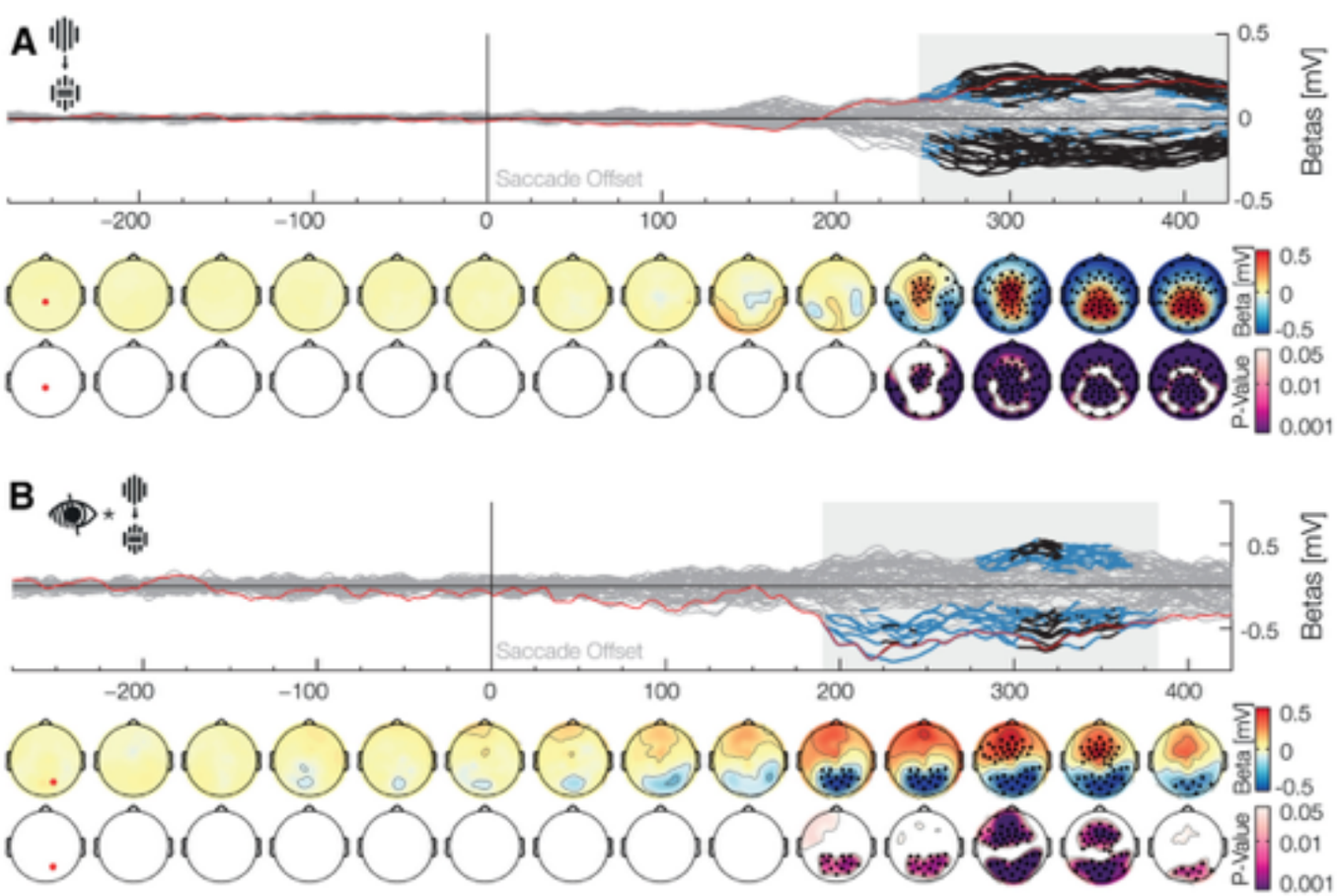
- Illusory occlusion affects depth perception (Chen et al., 2018)
- This suggests that filling-in can produce opaque surface representations that can trump other depth cues such as disparity.



(Un)Reliability of BS information

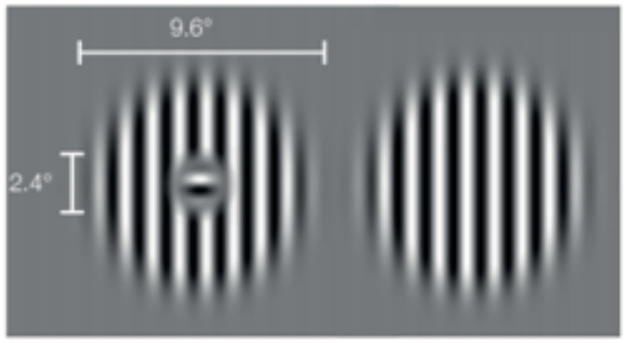


Predictions of Visual Content across Eye Movements and Their Modulation by Inferred Information *(Ehinger B., König P., Ossadon J., 2015)*

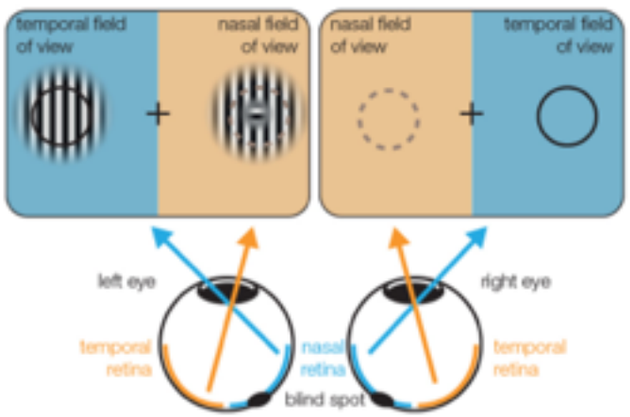


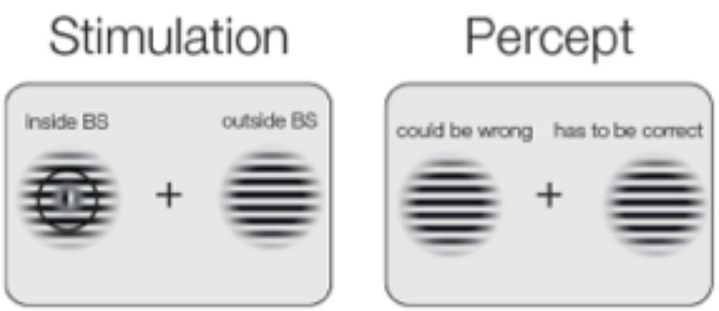
Choice Bias for unreliable, filled in Information

a



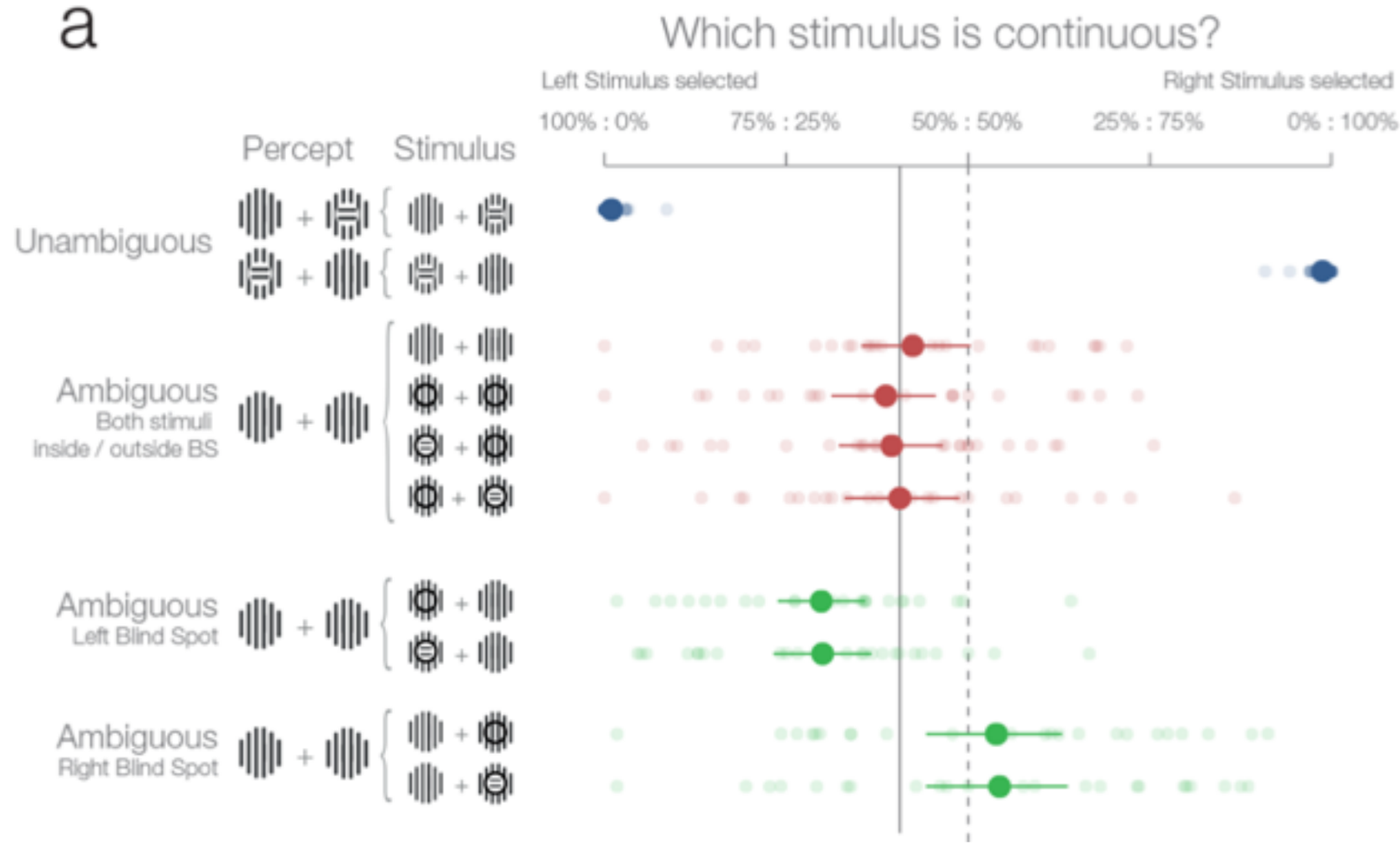
c





Humans treat unreliable filled-in percepts as more real than veridical ones. *(Ehinger, B. V., Häusser, K., Ossandón, J. P., & König, P., 2017)*

a

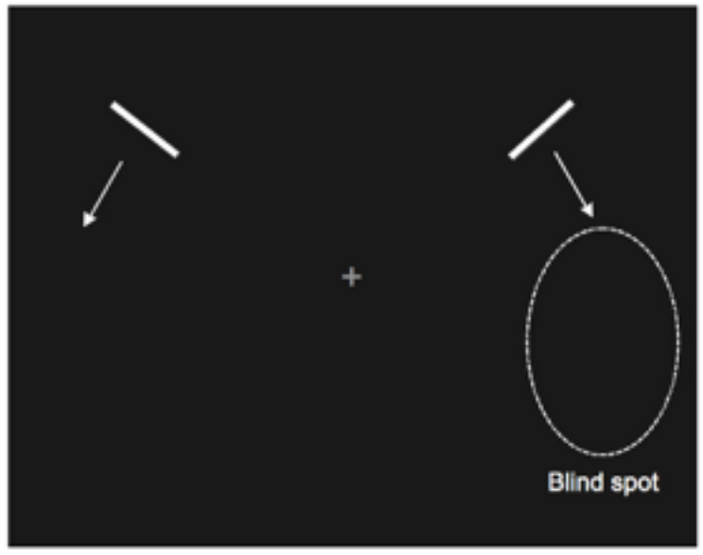


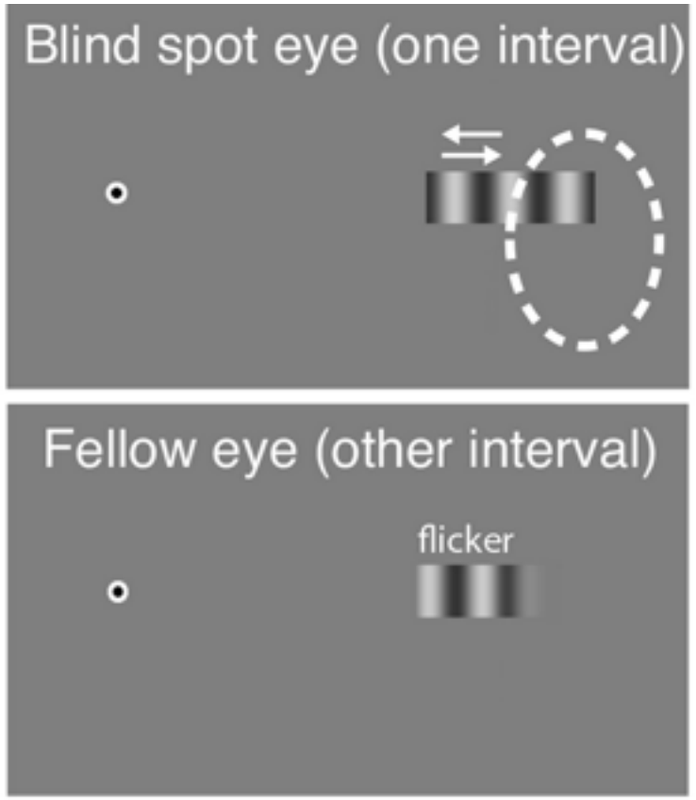
Prediction and the Blind Spot

- Influence of prediction onto blindspot
  - spatiotemporal extrapolation *(Maus and Nijhawan 2008, Maus and Whitney 2016, Tripathy, 2006)*
  - probabilistic inference?

Prediction and the Blind Spot

- Spatiotemporal extrapolation into the Blind spot *(Maus and Nijhawan, 2008)*
    - moving bar (comparable to Azzi et al., 2015)
        - perceived on average 3.1 deg shifted into direction of motion
- Motion dependent filling in of spatiotemporal information at the blind spot *(Maus and Whitney, 2016)*
    - drifting bar vs. flickering bar





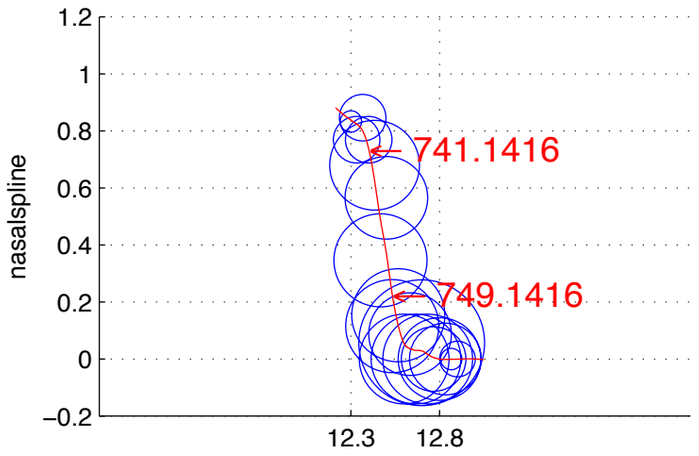
(Maus and Nijhawan, 2008, Maus and Whitney, 2016)

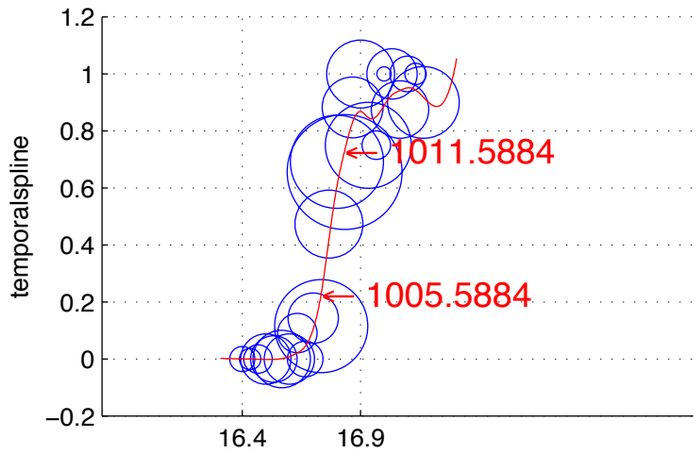
Next study

- Quantify the influence of prediction onto BS percept
- Why is BS border not perceived as BS border: orientation selectivity at BS border
- Beyond the blindspot's edge: is information weighed with certainty?
- transsaccadic integration at blind spot border (how are pre and post saccadic images merged if one is less reliable)

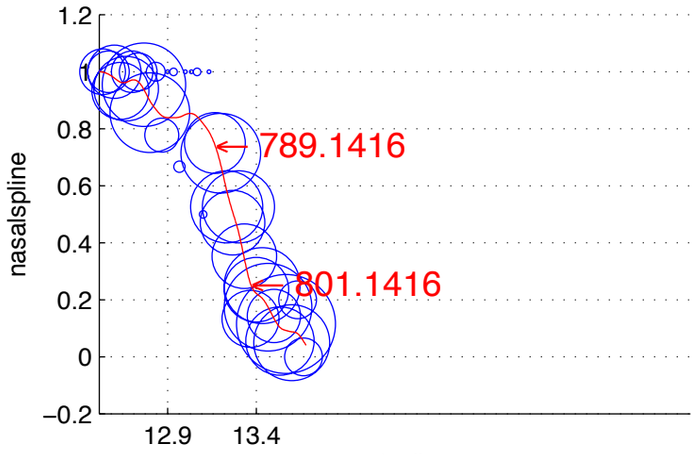
Corrected Aligned Data

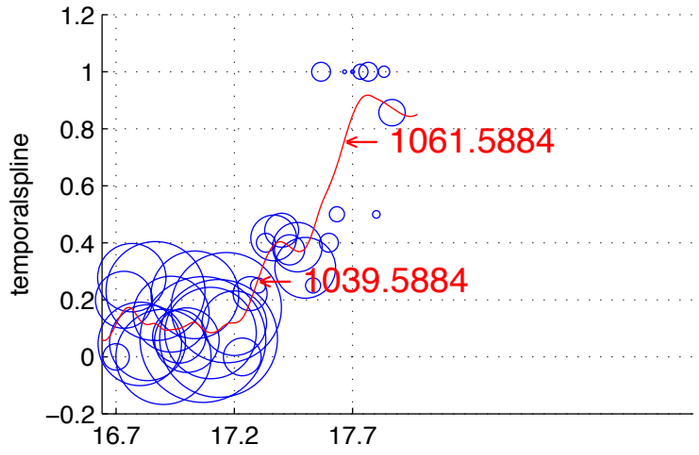
AM



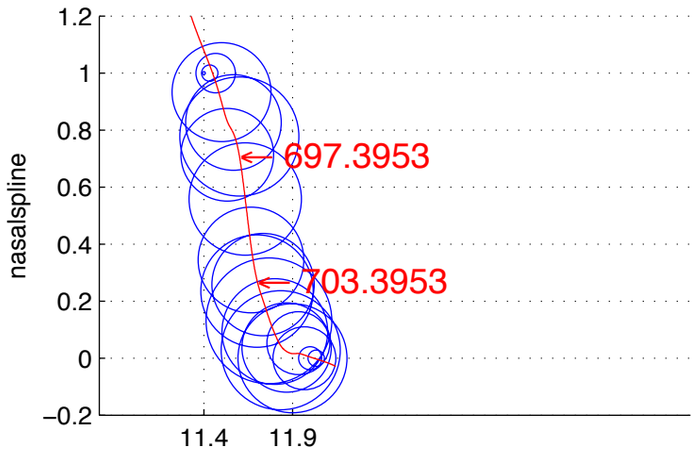


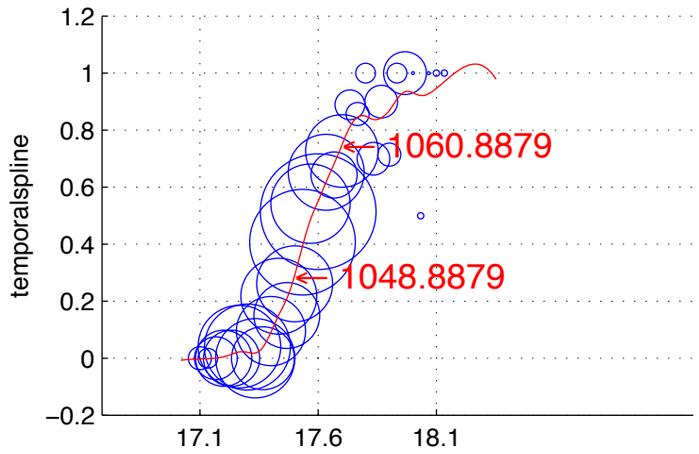
GM



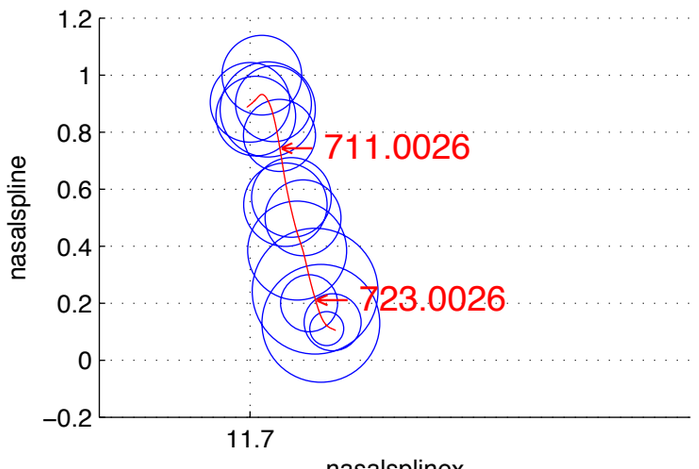


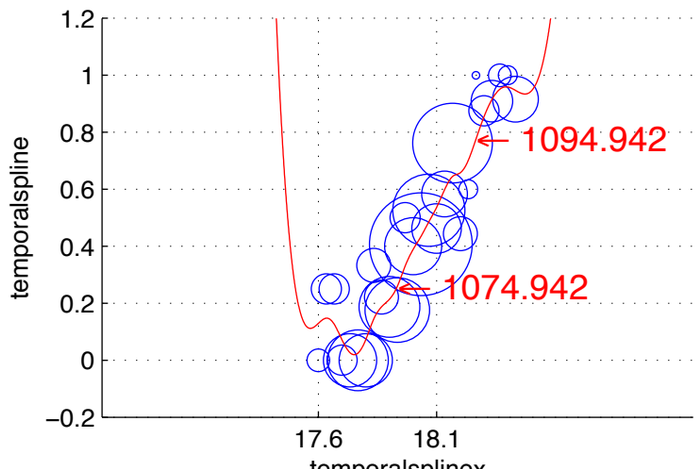
RE



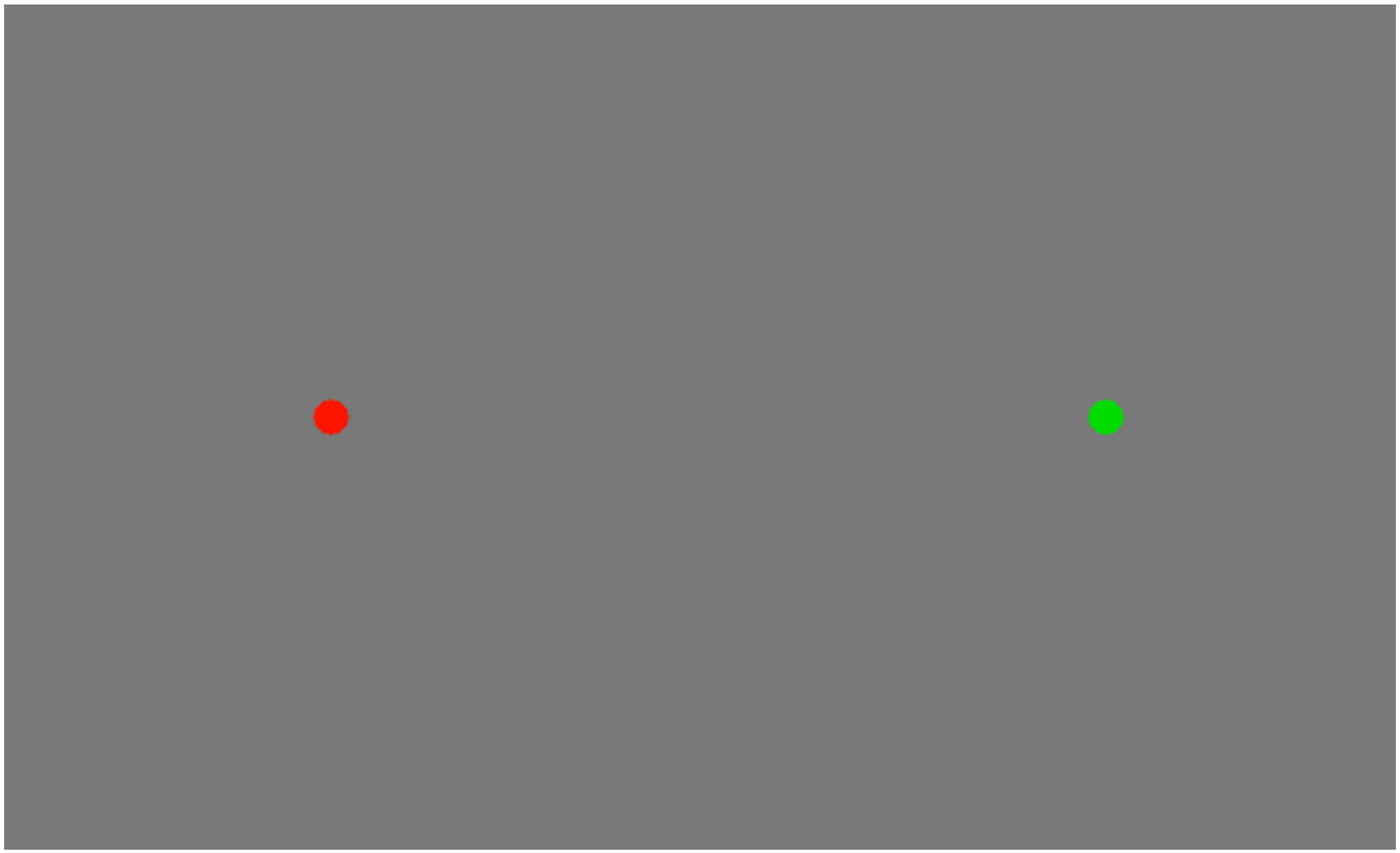


KS





Prediction

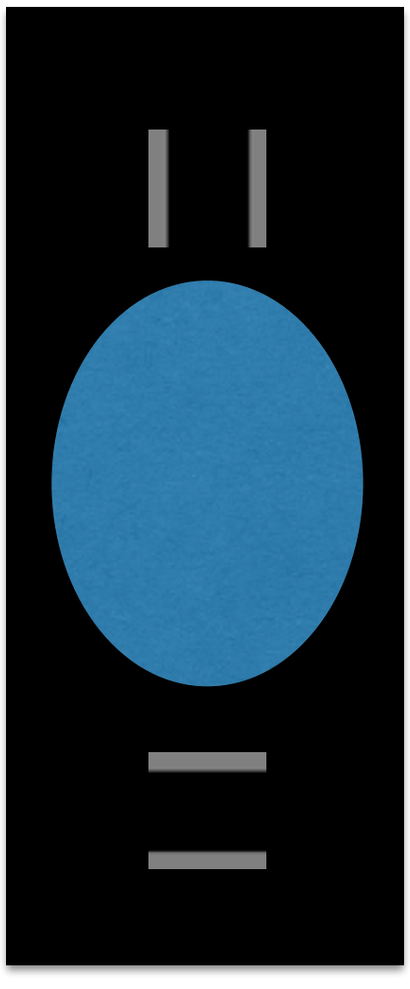


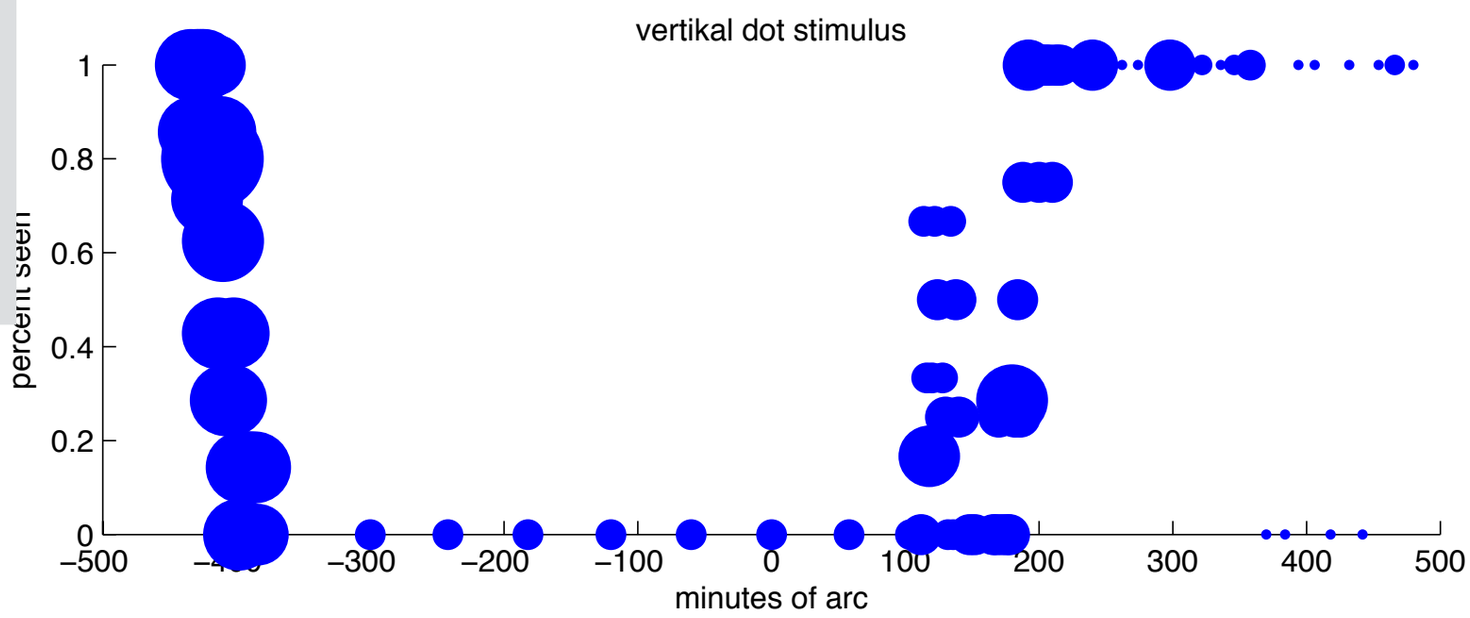
Context

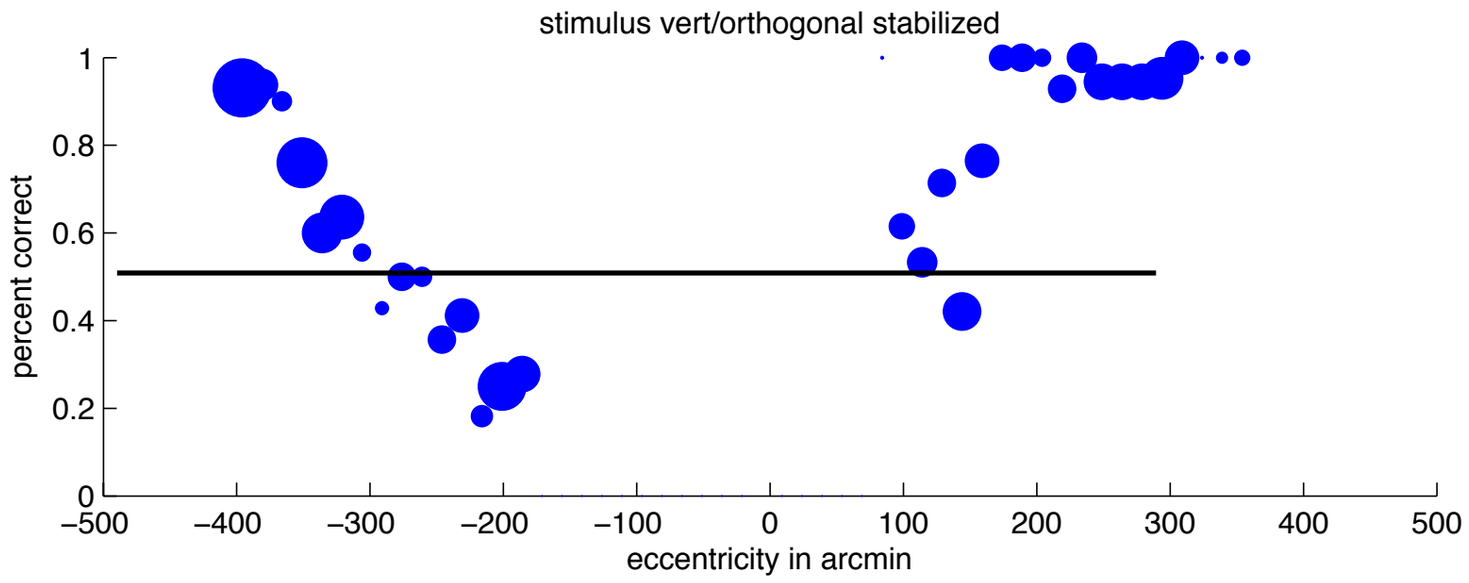
Orientation selectivity at BS border

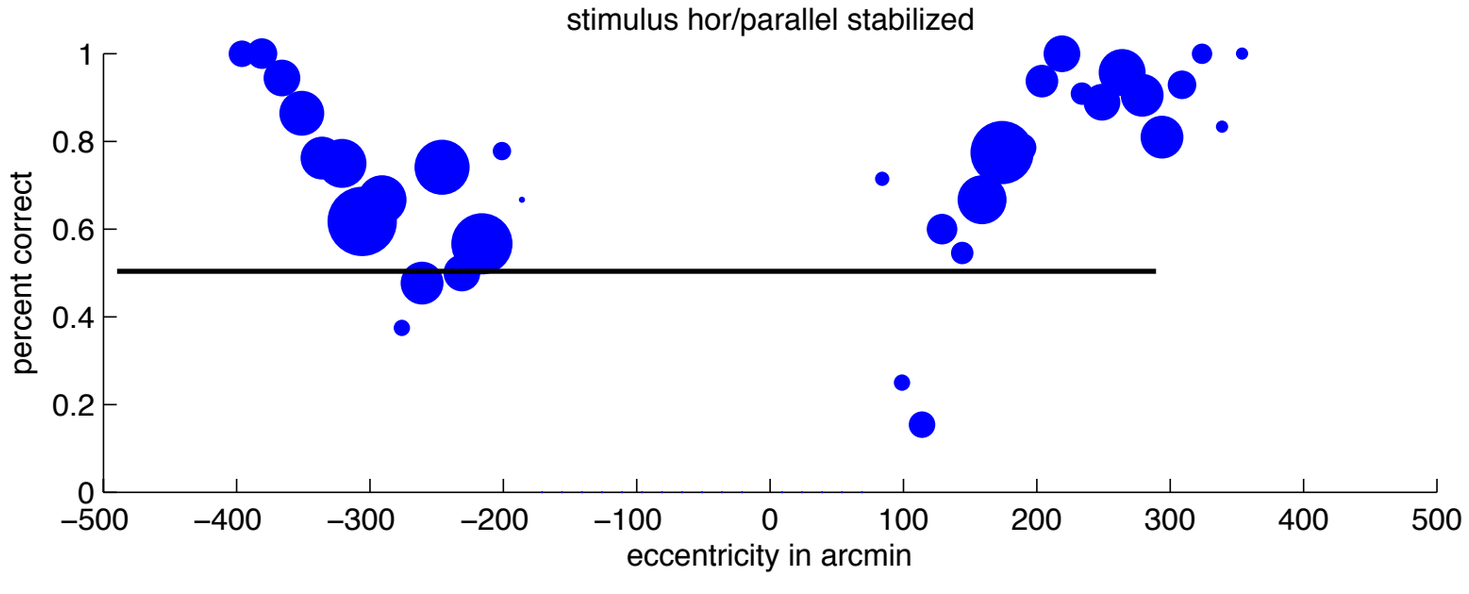
Dot stimulus,
2 arcmin square
flashed for 2 frames

Bar stimulus
40 arcmin
square
flashed for 140
ms
2AFC









Beyond the blindspot's edge: is information weighed with certainty?