PLAsticiTY of Perceptual space Under Sensorimotor interactions

European Commission

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

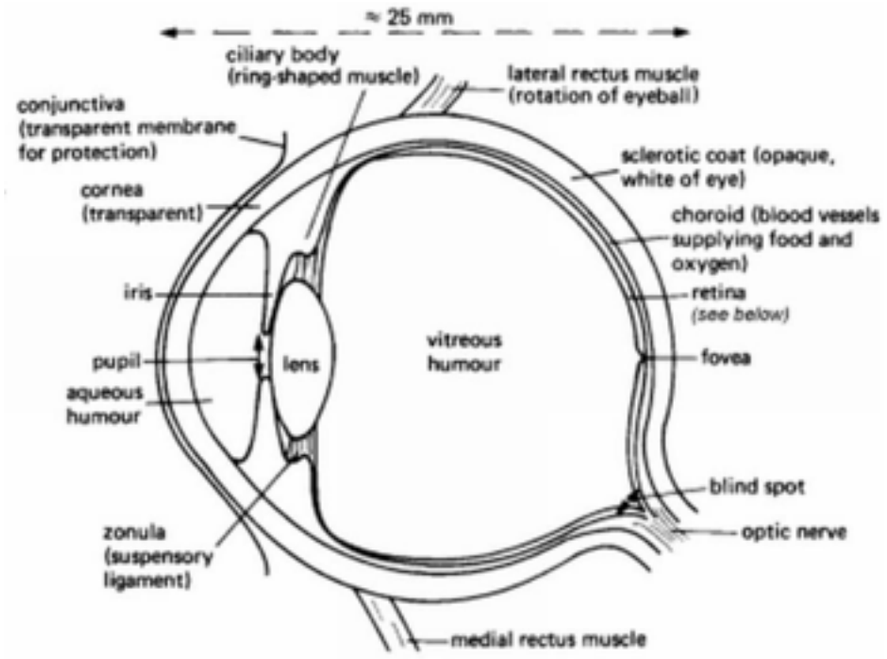
A gap in the map: the blind spot

Task 2.1

Task 2.1

…**First precise measurements of the edges of the blind spot** in the human eye will be undertaken using the highly controlled setup for fixational eye movements at BU in cooperation with WWU and UMR (Task 2.1). We will study the transition between the blind spot and the adjacent recipient part of the retina in detail in order to **determine the contribution of this transitional region to filling-in**….

Summary of the literature



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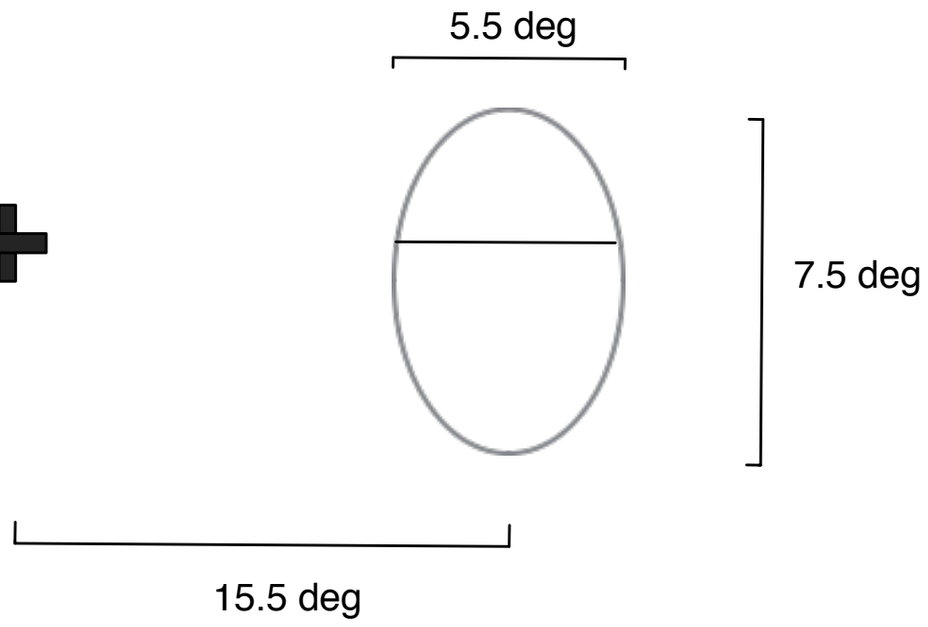
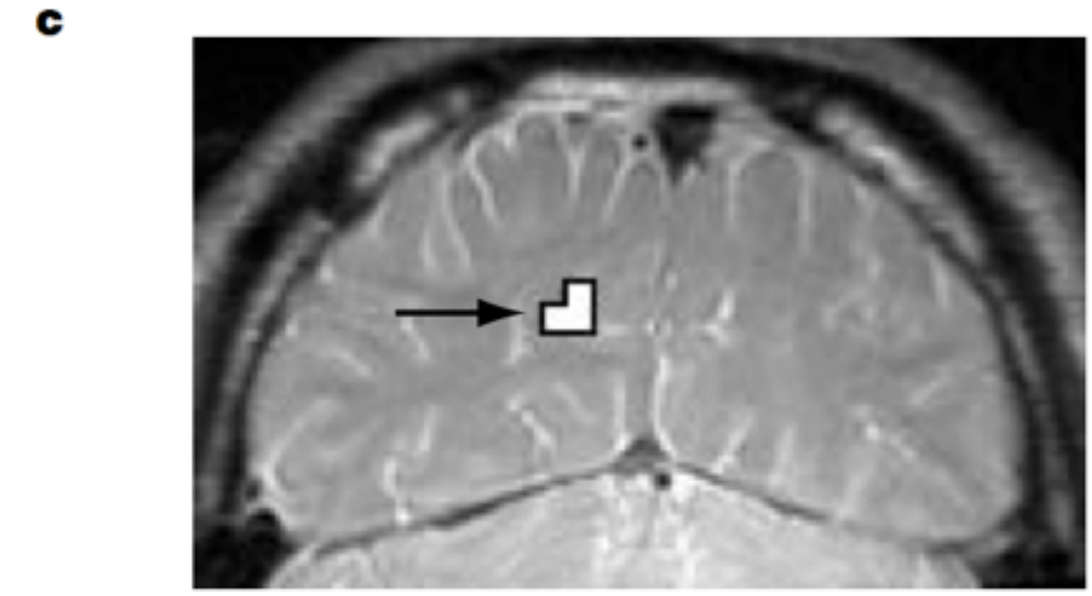


very heterogenous results -
depend on:
stimulus size
stimulus contrast
and way of measurement

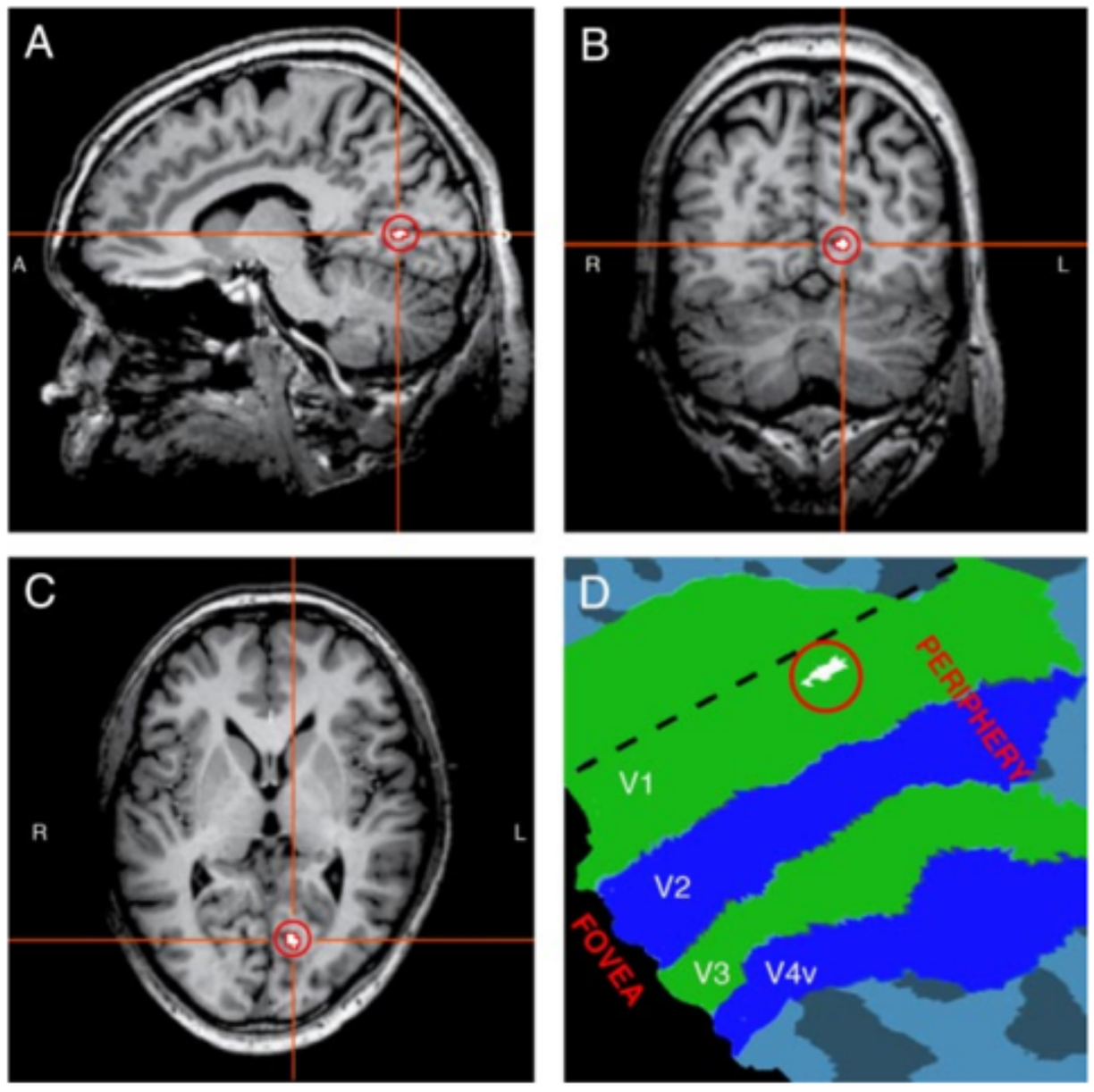
	widt	height
Dolderer et al.(2006)	4-5	4-5
Armaly (1969)	7.5	10
Safran (1993)	7.0	9.2
Harrington (1976)	5.5	7.5
Chamlin (1960)	6.87	7.4
Traquair (1948)	5.5	7.7

Neurophysiological underpinnings



Representation of blind spot in V1 figure from Tong and Engel (2001)

Cortical region corresponding to the anatomical and functional blind spot lies anterior to the occipital pole in V1 *(Awater et al., 2005; Tong and Engel 2001; Tootell et al., 1998)*



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

Characteristics of the blind spot

- Blind spot has a representation in V1 *(monkey: Azzi et al. 2015; human: Awater et al., 2005),* i.e. there are receptive fields in the V1 map that represent the space of the blind spot in the retinal image

- Large and discontinuous receptive fields for neurons in V1 probably responsible for completion process *(Fiorani et al.,1992; Komatsu et al. 2000,2002; Komatsu, 2006; Matsumoto & Komatsu, 2005)*

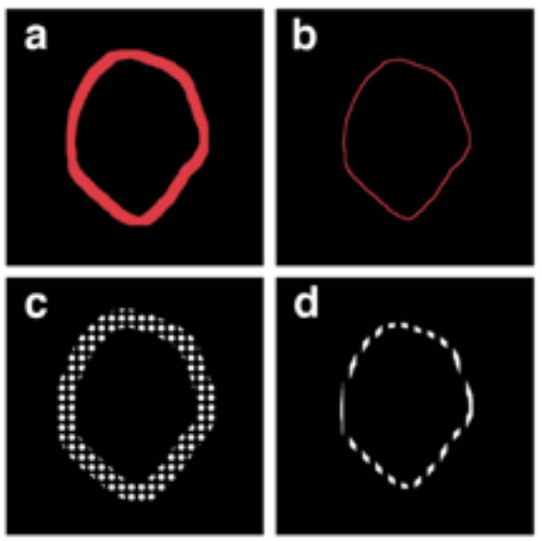


figure from Spillmann et al. (2006)

- Size of the blind spot varies between subjects, borders are irregular. Minimal stimulation area surrounding the blind spot to achieve filling in needs to be 0.05 deg wide *(Spillmann et al., 2006)*

- Nasal slope is steeper than temporal slope *(Safran et al., 1993)*

- Visual field is not distorted around the blind spot *(Tripathy et al., 1996; Awater et al., 2005)*

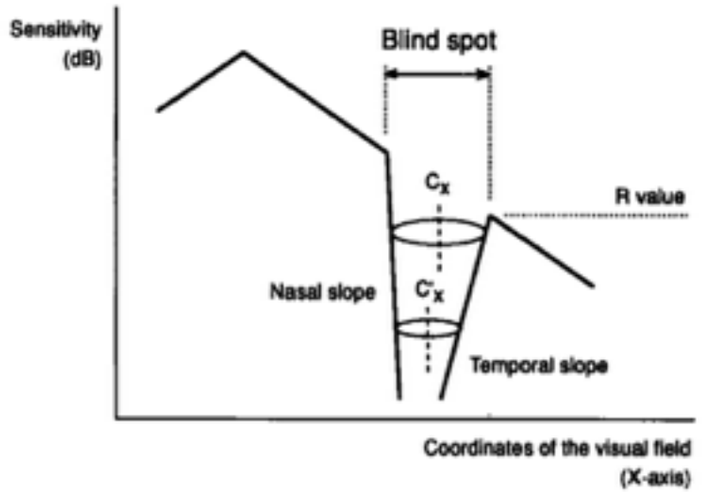


figure from Safran et al. (1993)

How functionally blind is the blind spot?

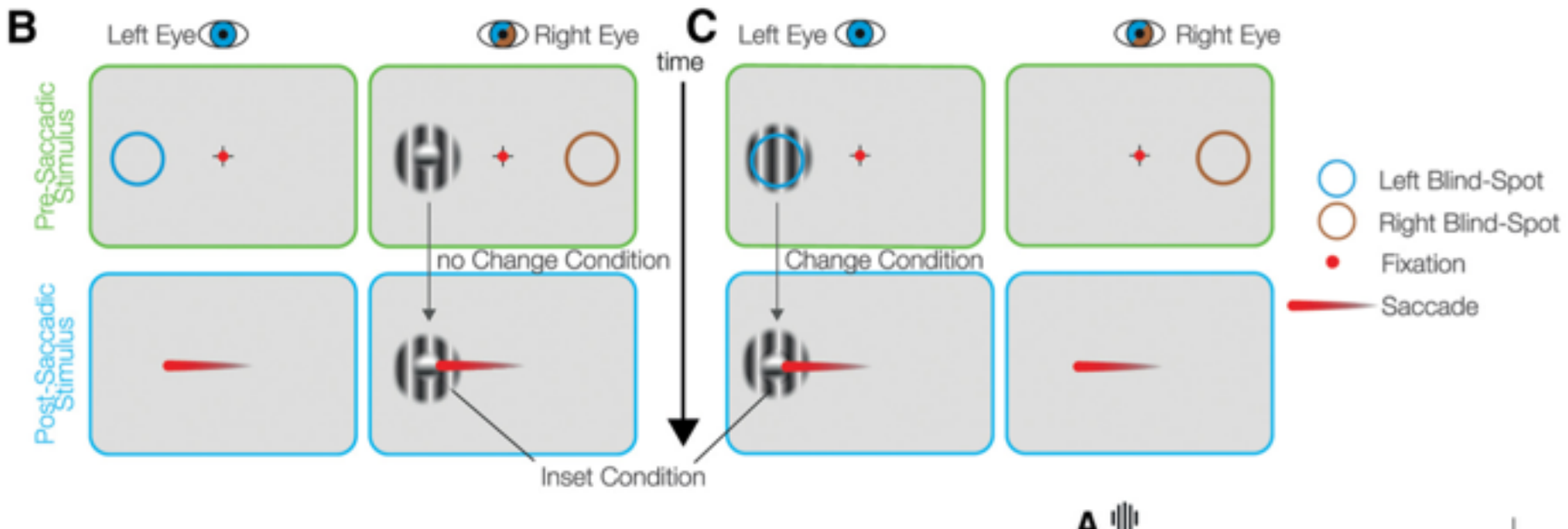
- Filling-in works either by lateral propagation (8 mm) or feedforward connections (up to V2, then feedback into V1) *(Azzi et al., 2015; Matsumoto & Komatsu, 2005)*

- Stimulation of the blind spot in one eye can induce motion after-effects in the fellow eye *(Murakami,1995)*

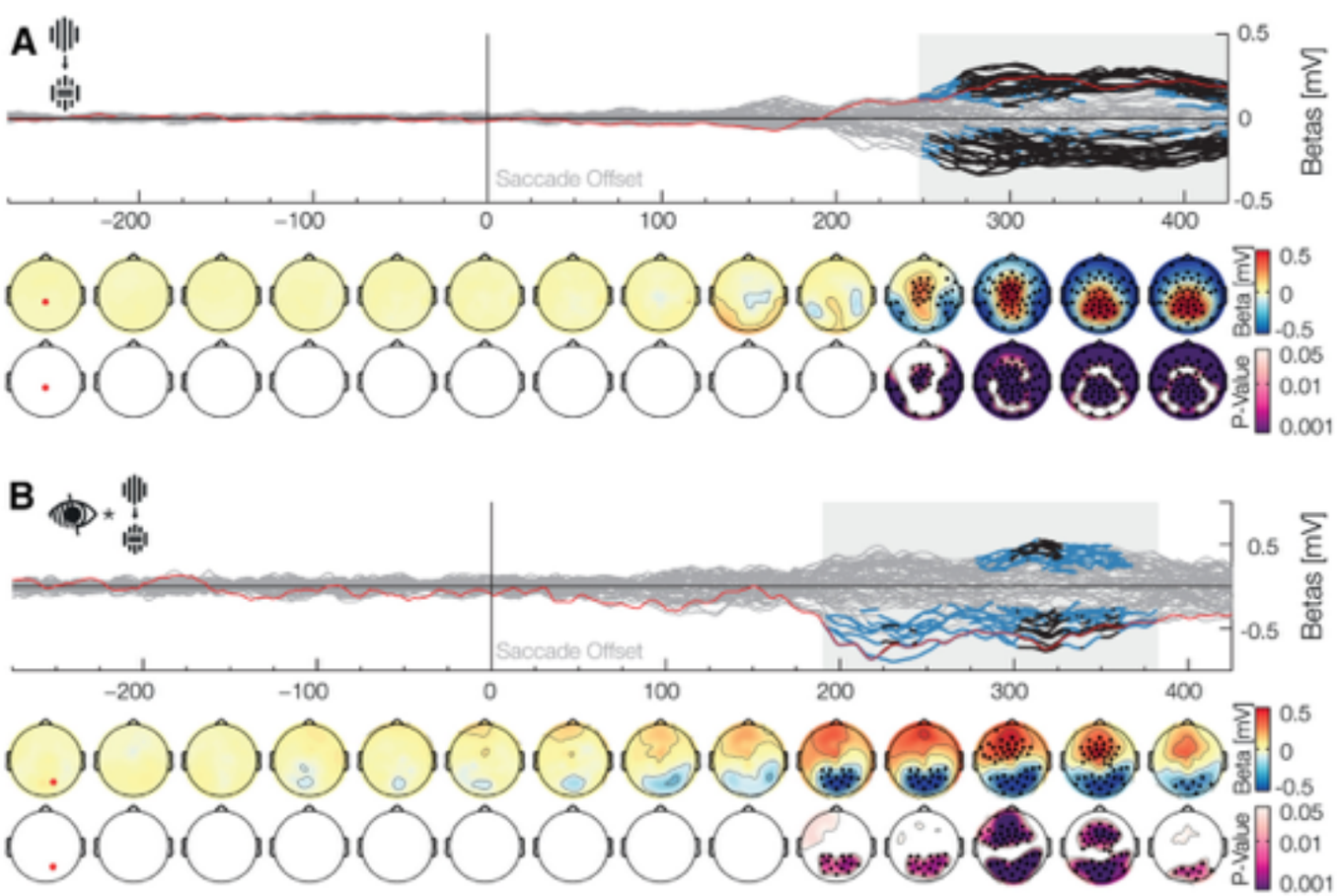
- Filled-in grating can induce binocular rivalry in the fellow eye *(Tong & Engel, 2001)*

- Motion extrapolation into the blind spot *(Maus et al., 2008, Maus et al., 2016)*

How functionally blind is the blind spot?

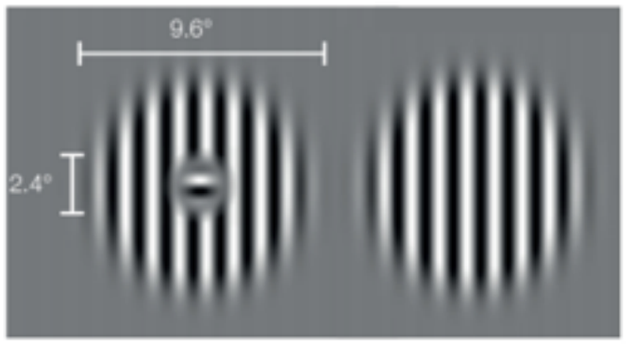


Predictions of Visual Content across Eye Movements and Their Modulation by Inferred Information *(Ehinger B., König P., Ossadon J., 2015)*



How functionally blind is the blind spot?

a



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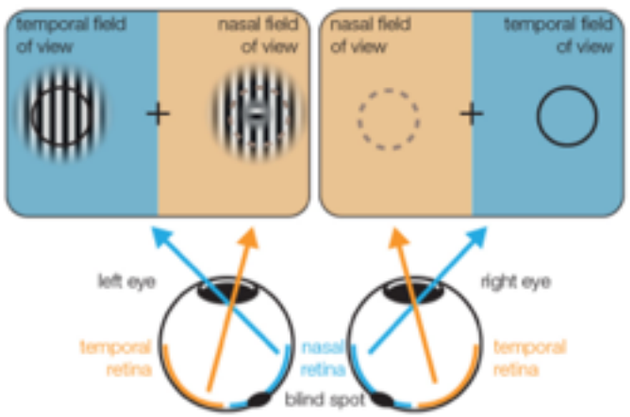

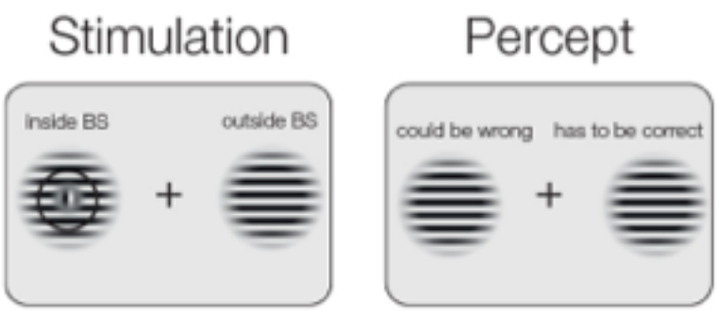

Humans treat unreliable filled-in percepts as more real than veridical ones. *(Ehinger, B. V., Häusser, K., Ossandón, J. P., & König, P., 2017)*

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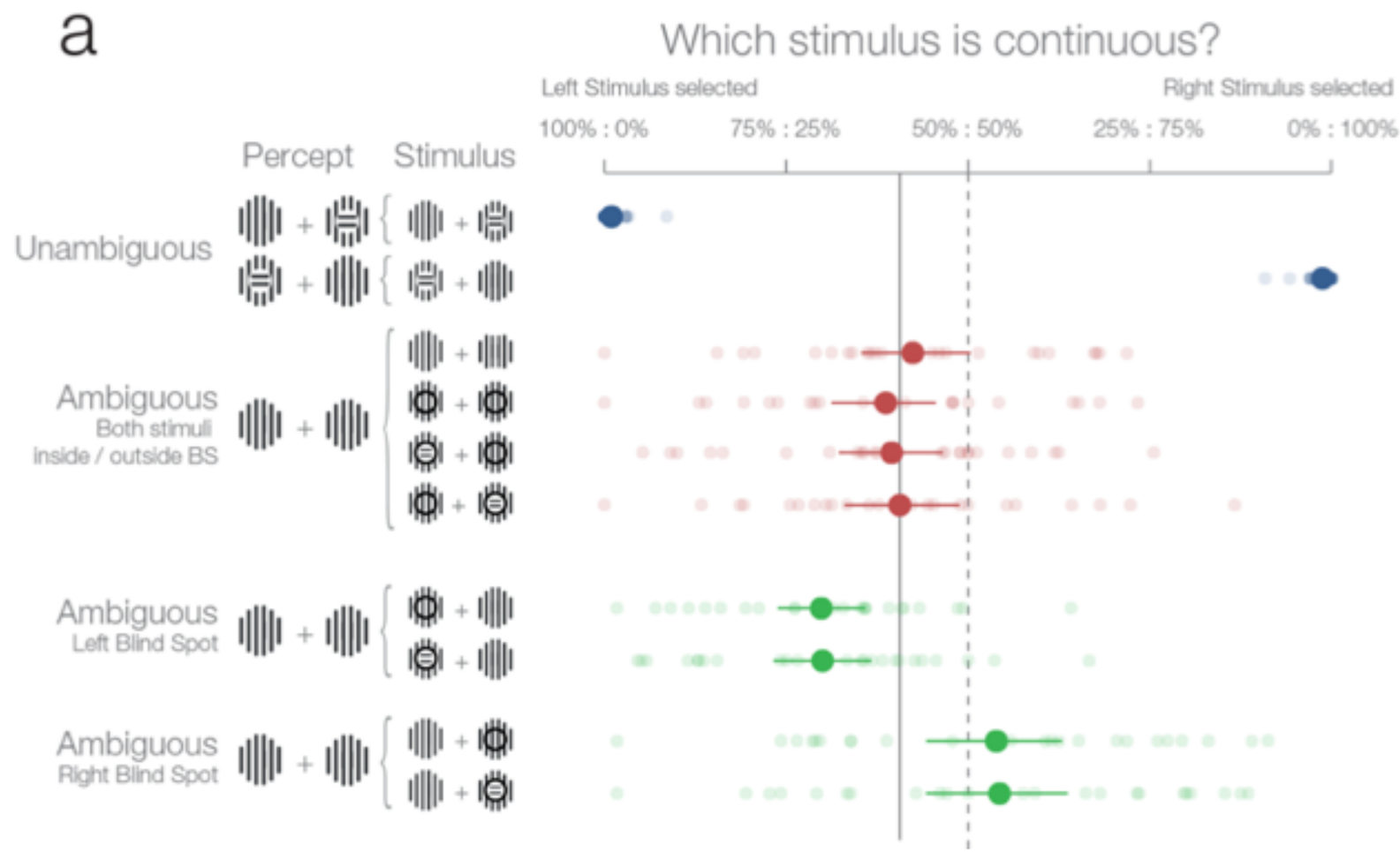
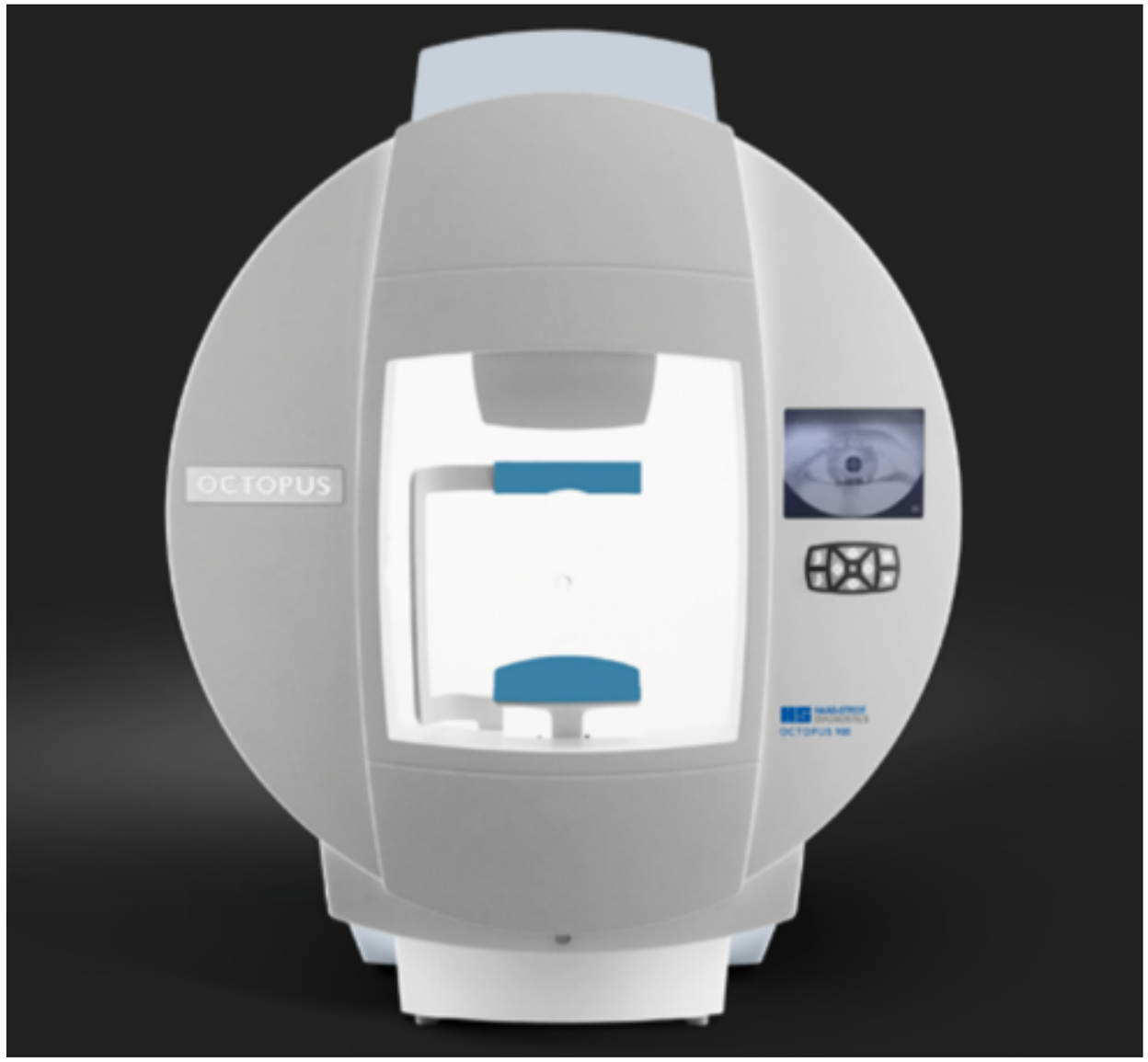


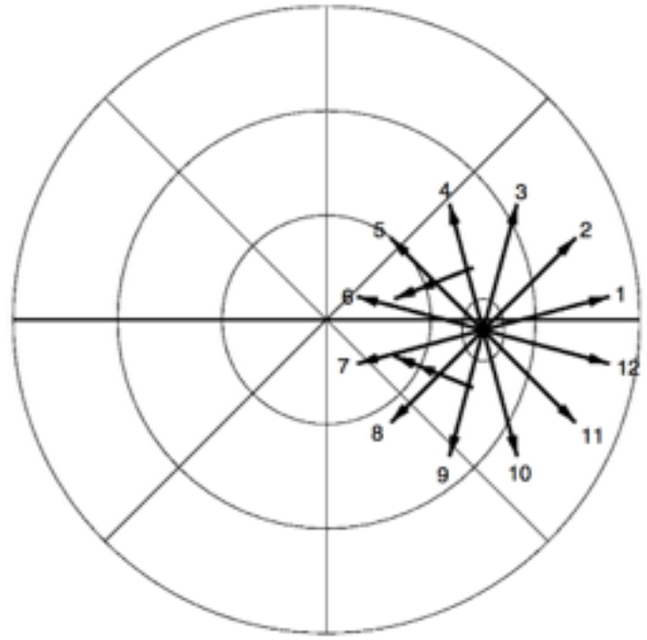
Measurement of the blind spot

- by ophthamologists in clinical and normative studies
- by neuroscientists that use the blind spot as a tool (region of no retinal input)

Optometry

- Measurement with a perimeter





Dolderer et al., (2006)
Measurement with perimeter CTT
probably similar with Octopus900

Determining the blind spot in functional studies

1) The subject moves a small stimulus (flickering circle /red cross) around the border of the blind spot and clicks when it is just inside the blind spot.
(Spillmann et al., 2006; Maus et al., 2016; Maus and Nijhawan, 2008, Chen et al., 2017)

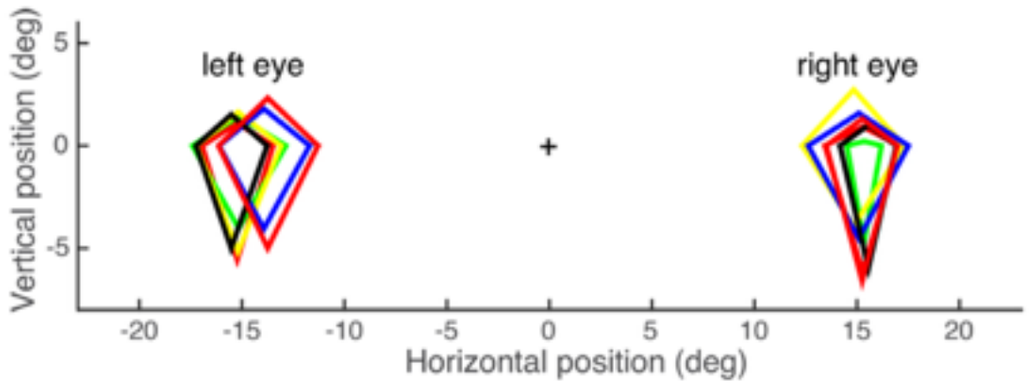


figure from Maus et al. (2016)

2) The subject adjusts a disc (flickering /filled red) as big as possible at the location of the blind spot *(Ehinger et al. 2015, 2017; Qian, 2017)*

3) In Baek *(2012)* a point moves at a constant speed through the blind spot. Subject presses button when the point disappeares.

How to map the blind spot border

- avoid predictions (randomized positions of stimuli)
- gaze contingent display of the stimulus
- stationary stimuli (preferrably small, short presentation times)
- inner border of blind spot is at ~12 deg, working with LED panel might be necessary

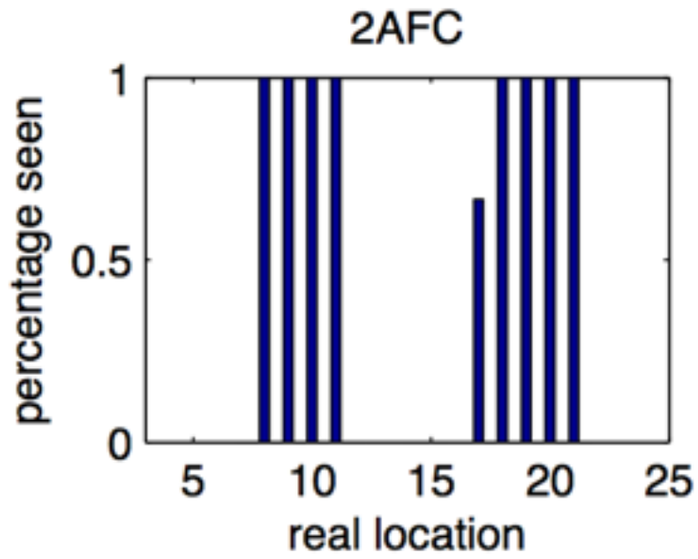
Preliminary data

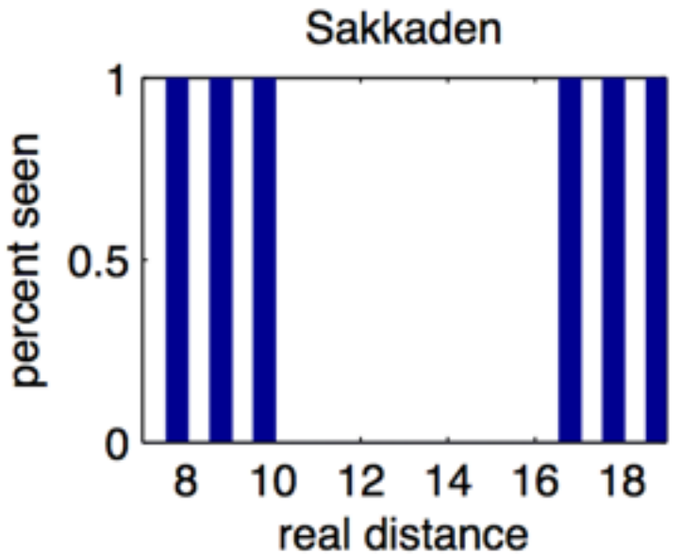
- Eyelink 1000
- gaze contingent display of the target
- black target (1.5deg * .3deg) background [170 170 170], flashed for 1 frame (17 ms) or 200 ms at meridian
- 3 types of answering: 2 AFC, saccade to target, localize target by mouseclick

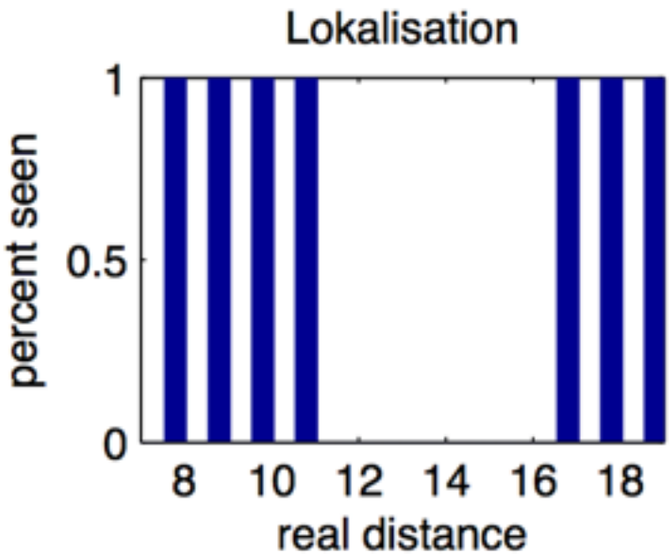
Subject 1

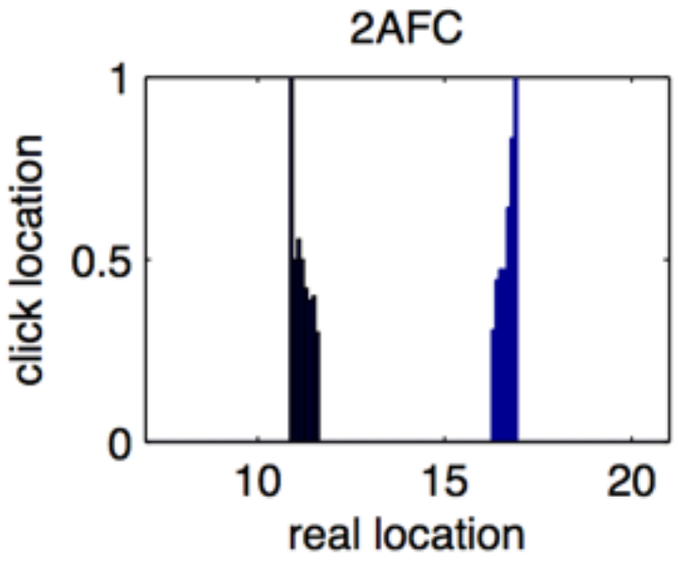
17 ms

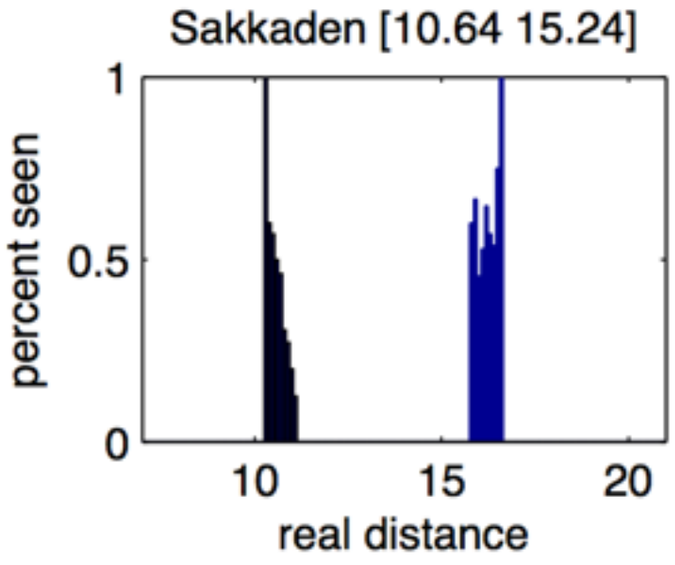
200 ms

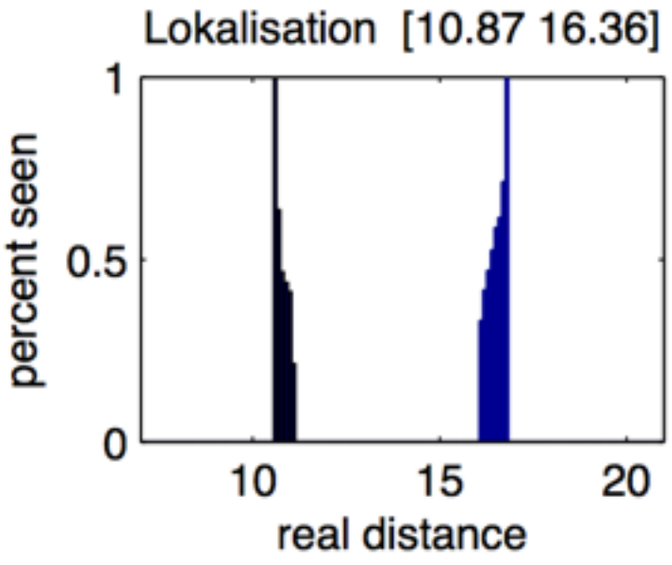


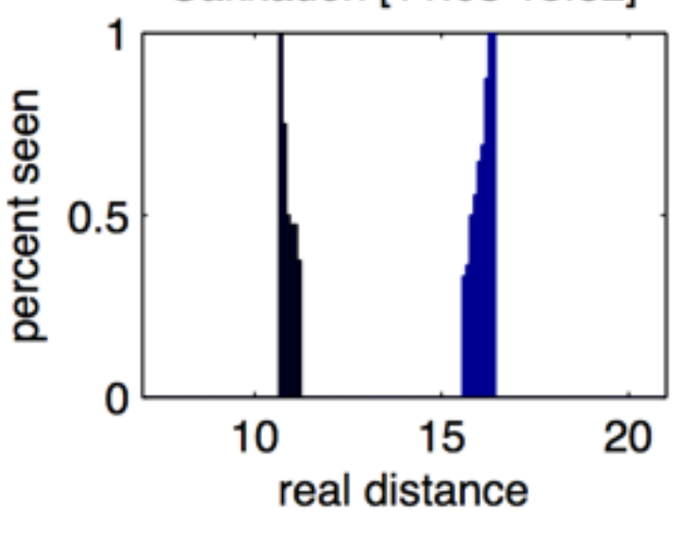


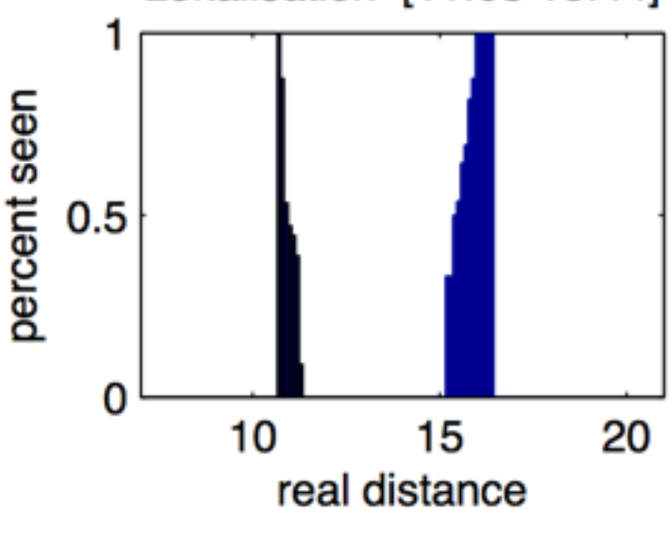












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Subject 2

17 ms

200 ms