

Learning where to look: A foveated visuomotor control model

Emmanuel Daucé, Pierre Albigès & Laurent Perrinet



CNS*2019, 15/7/2019

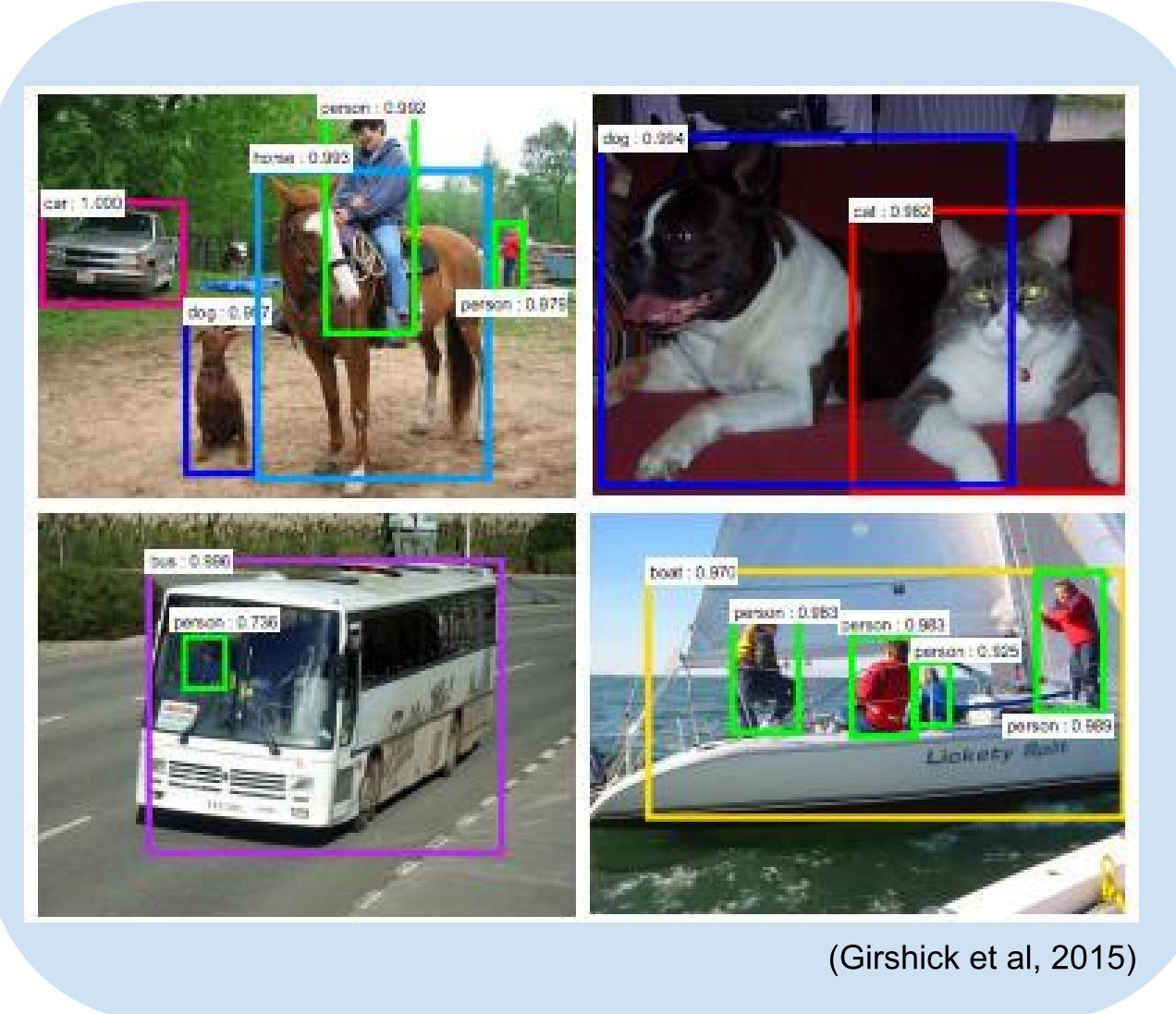
Outline

1. Motivation
2. Methods
3. Results
4. Conclusion

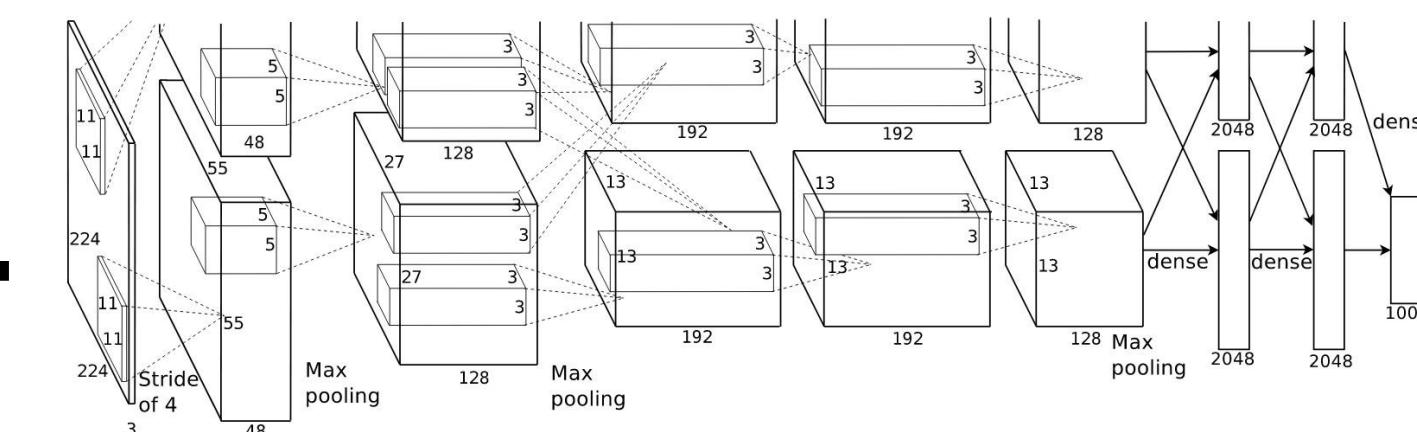
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Computer vision

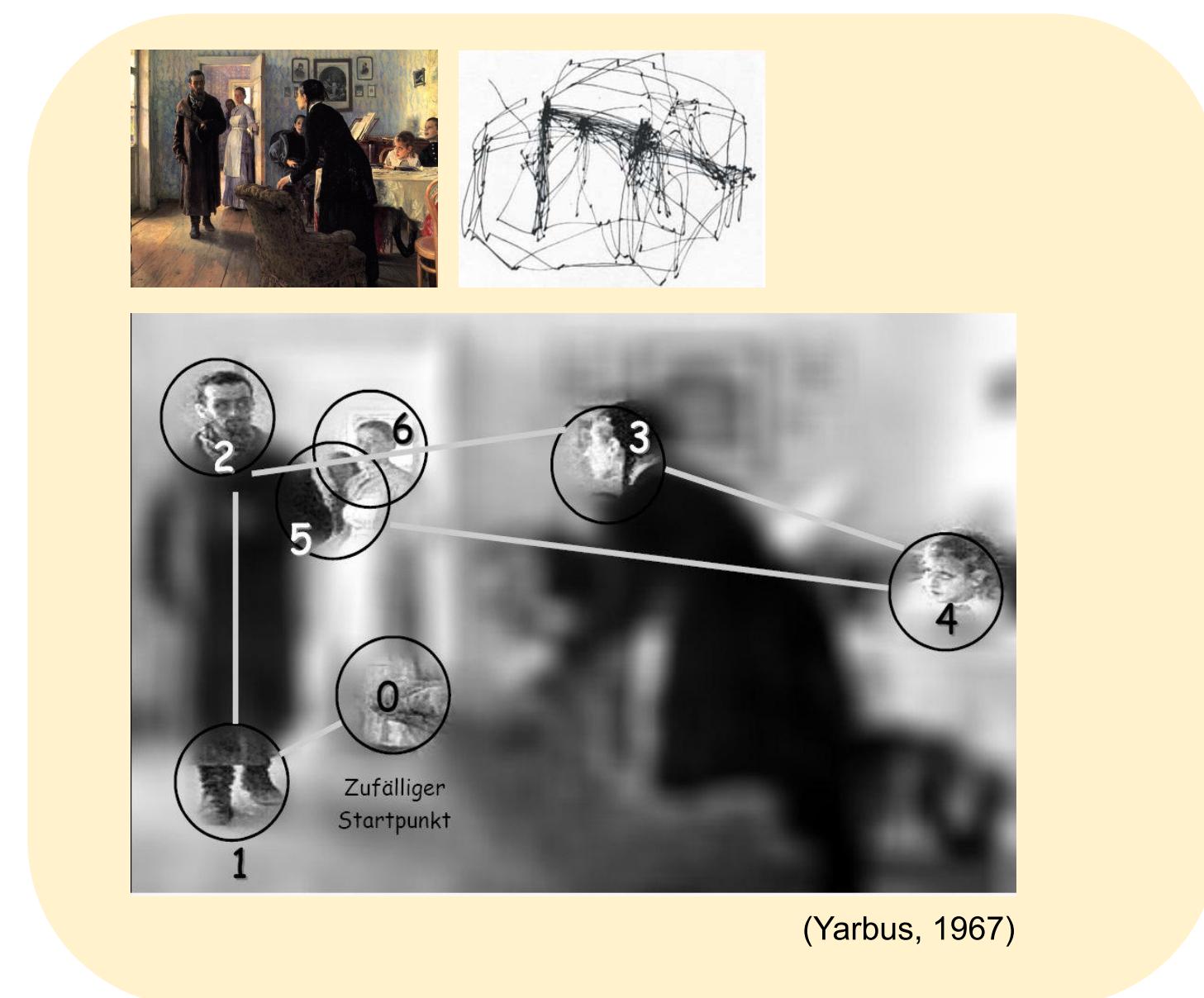
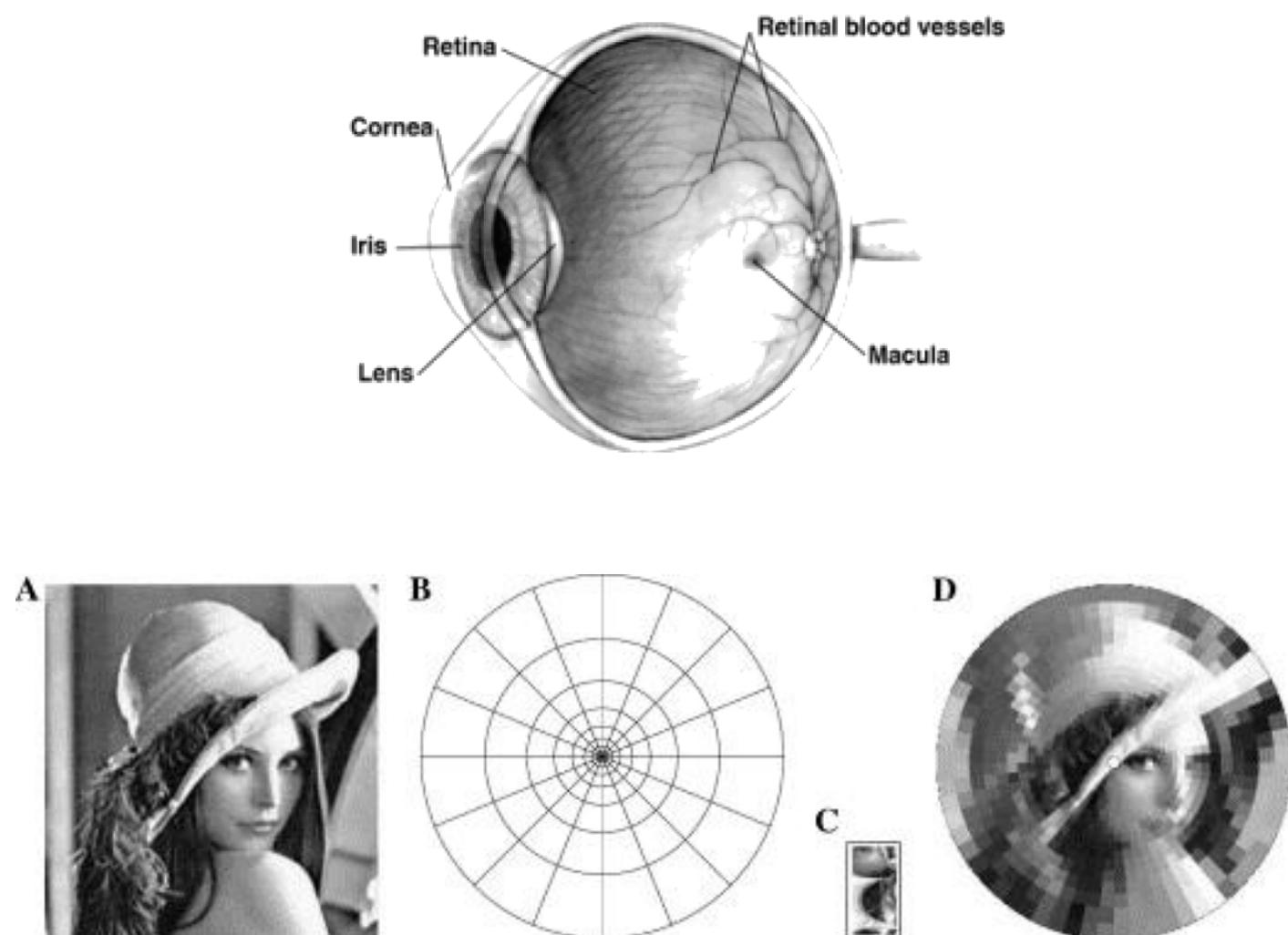


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(Hinton et al, 2012)

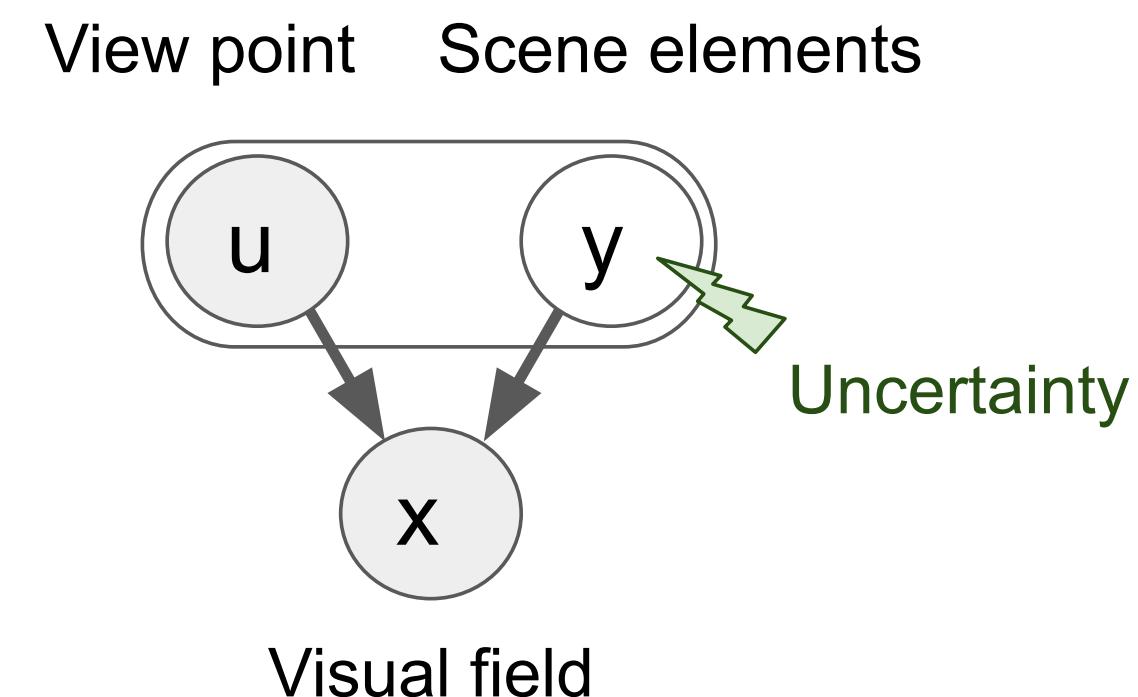
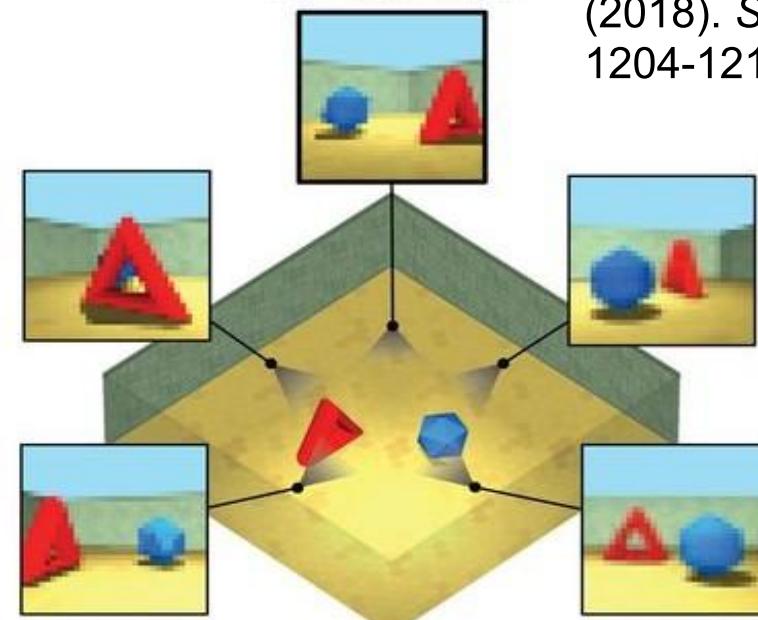
Human vision



(Yarbus, 1967)

Statistical Viewpoint

Eslami, S. A., Rezende, et al.
(2018). *Science*, 360(6394),
1204-1210.



Attention vs. Scene Understanding

Bayesian surprise
(Information Gain)

(Itti & Baldi, 2009)

$$E_y [\log P(Y|x, u) - \log P(Y)]$$

B O T T O M - U P

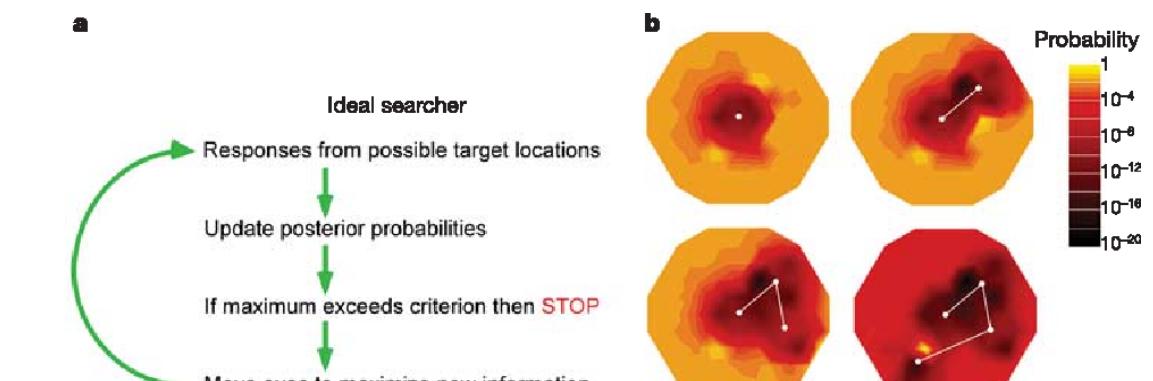
Visual attention
Saliency Maps



Itti and Koch (2000)
Kümmerer et al (2015)

T O P - D O W N

Active Inference
Recurrent Attention



Najemnik, J., & Geisler, W. S. (2005)
Butko & Movellan (2010)
Fu et al (2017)

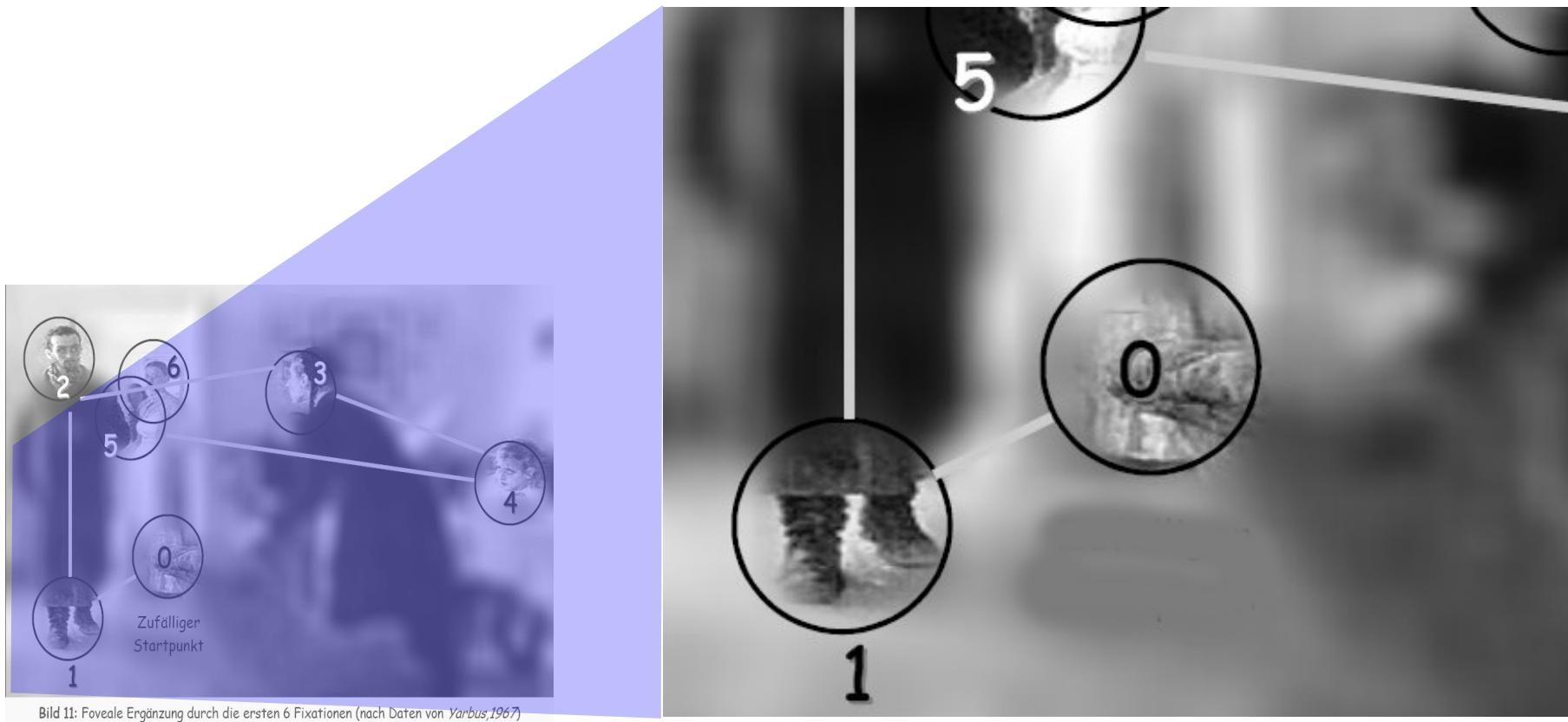
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Principles for central and peripheric vision

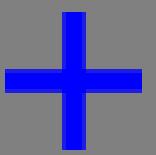


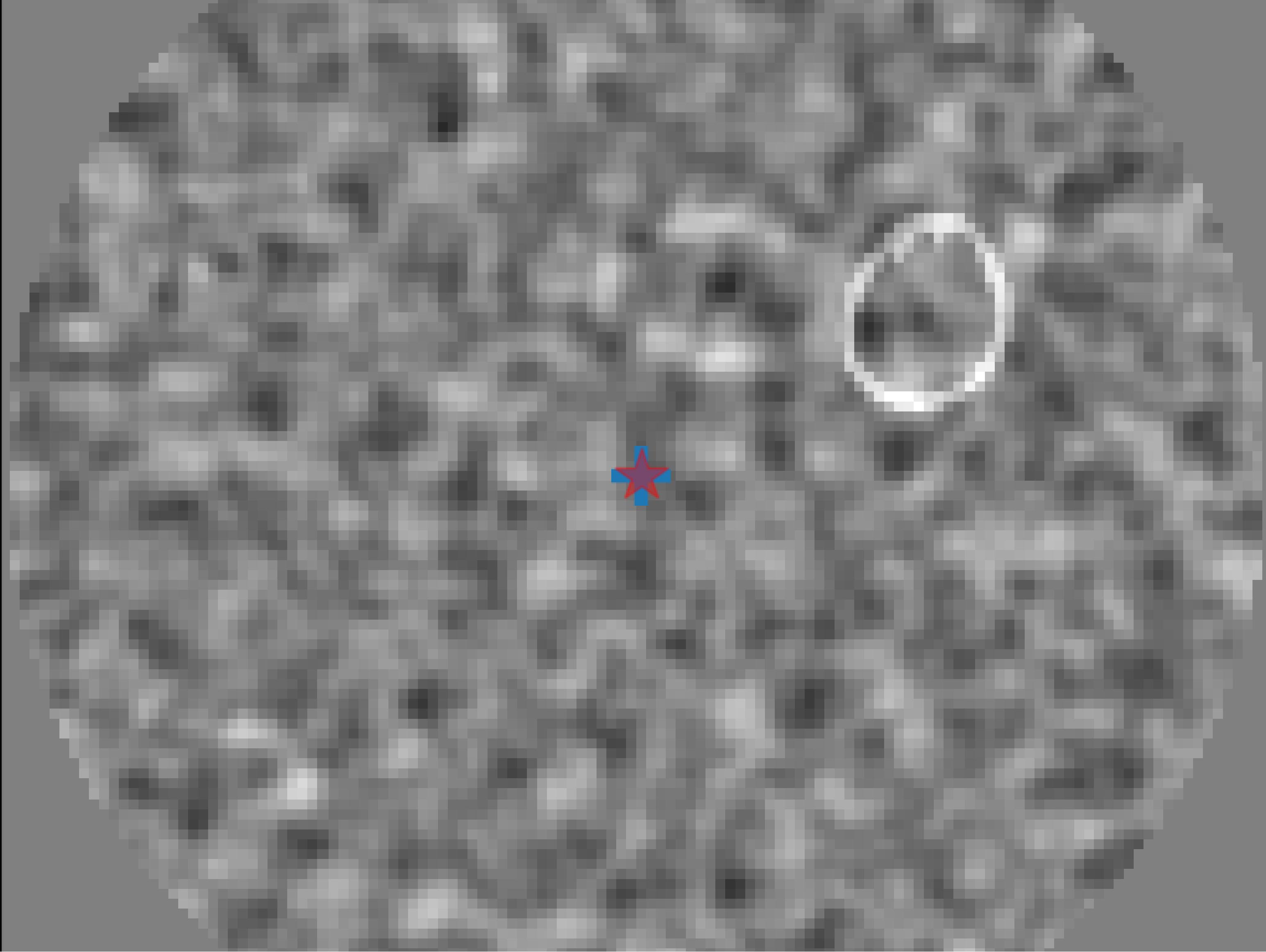
Information Gain :

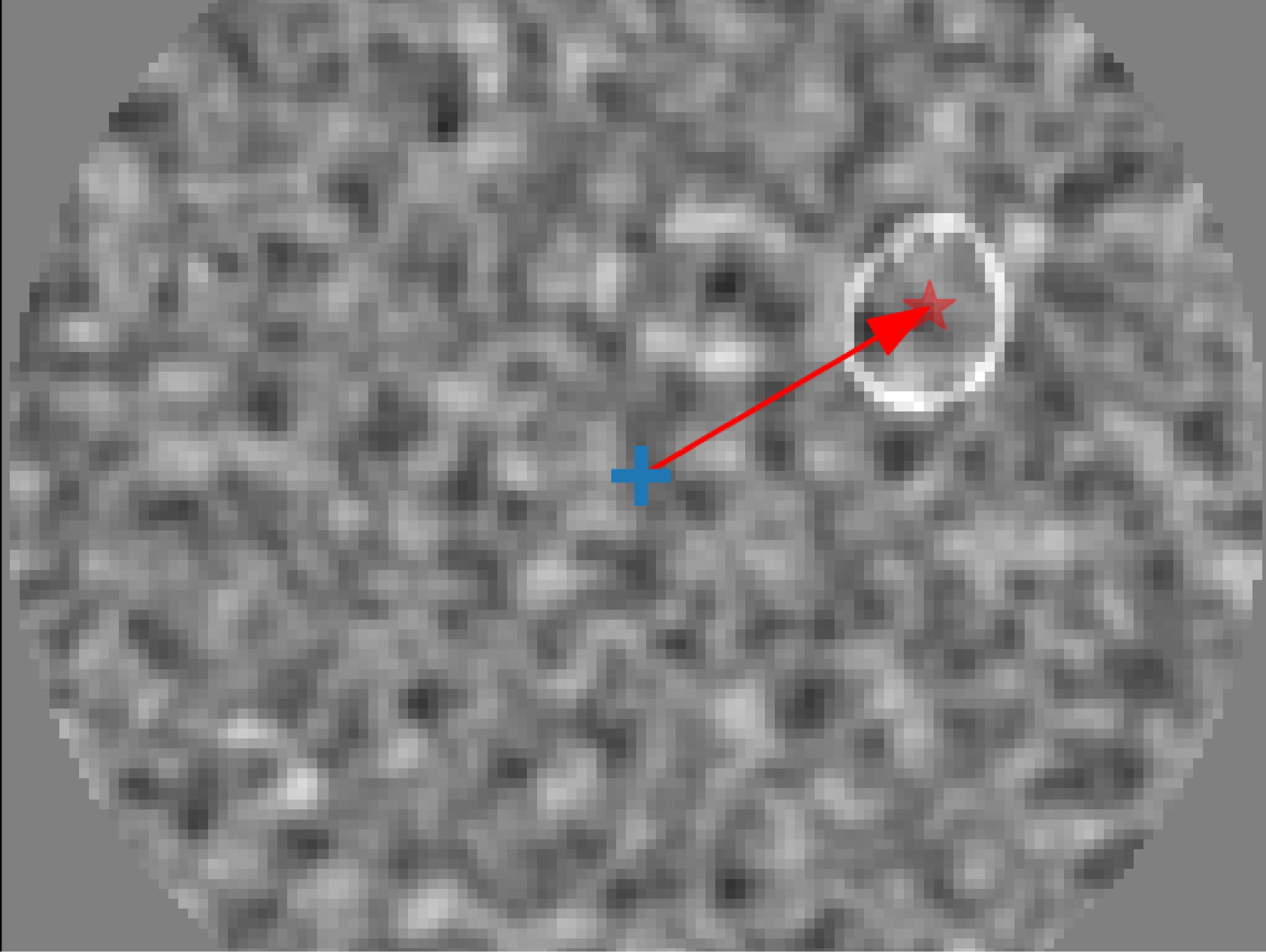
$$E_y [\log P(Y|x, u) - \log P(Y)]$$

Peripheral processing

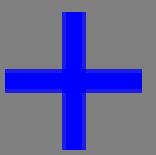
Central processing

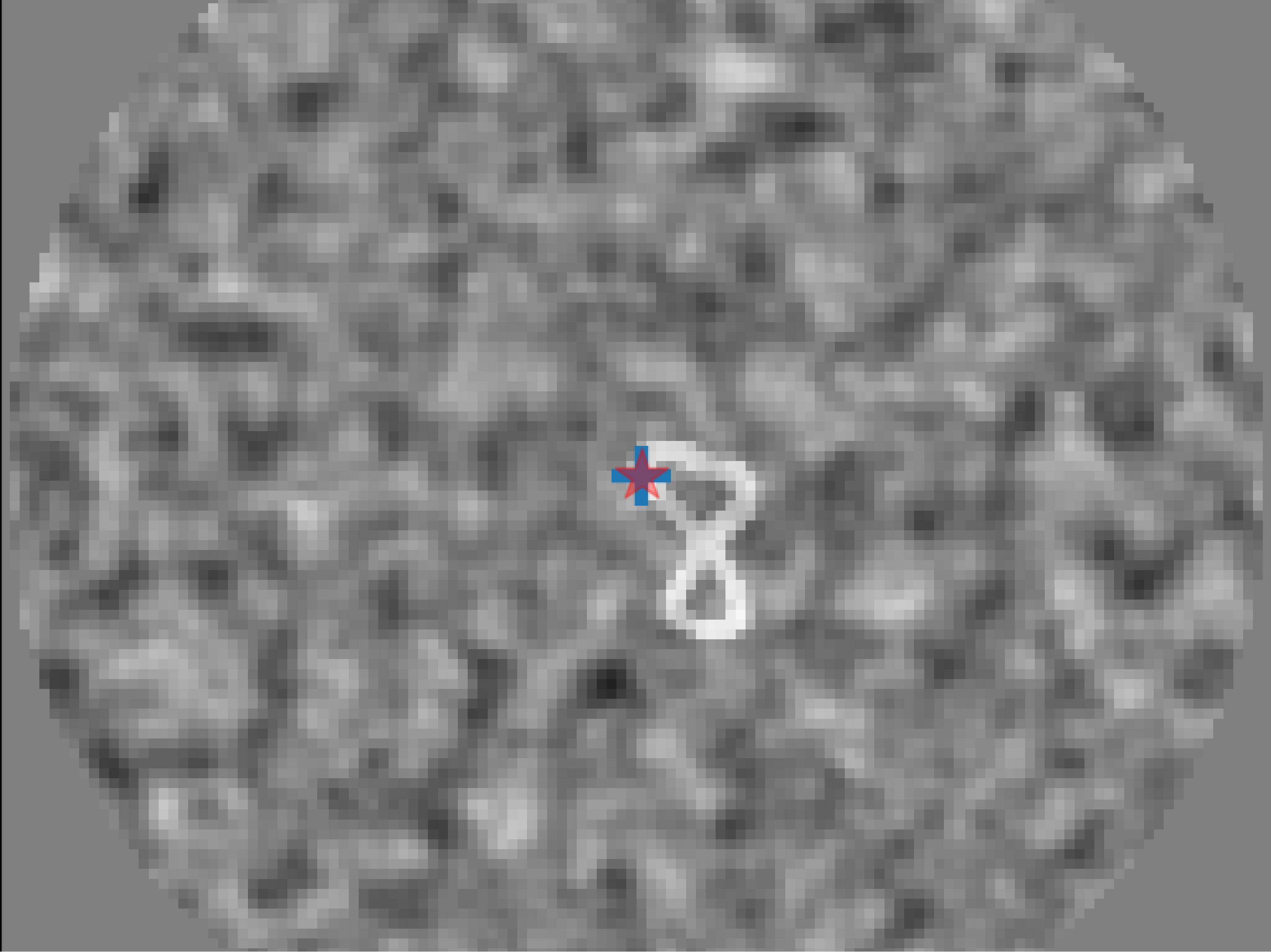


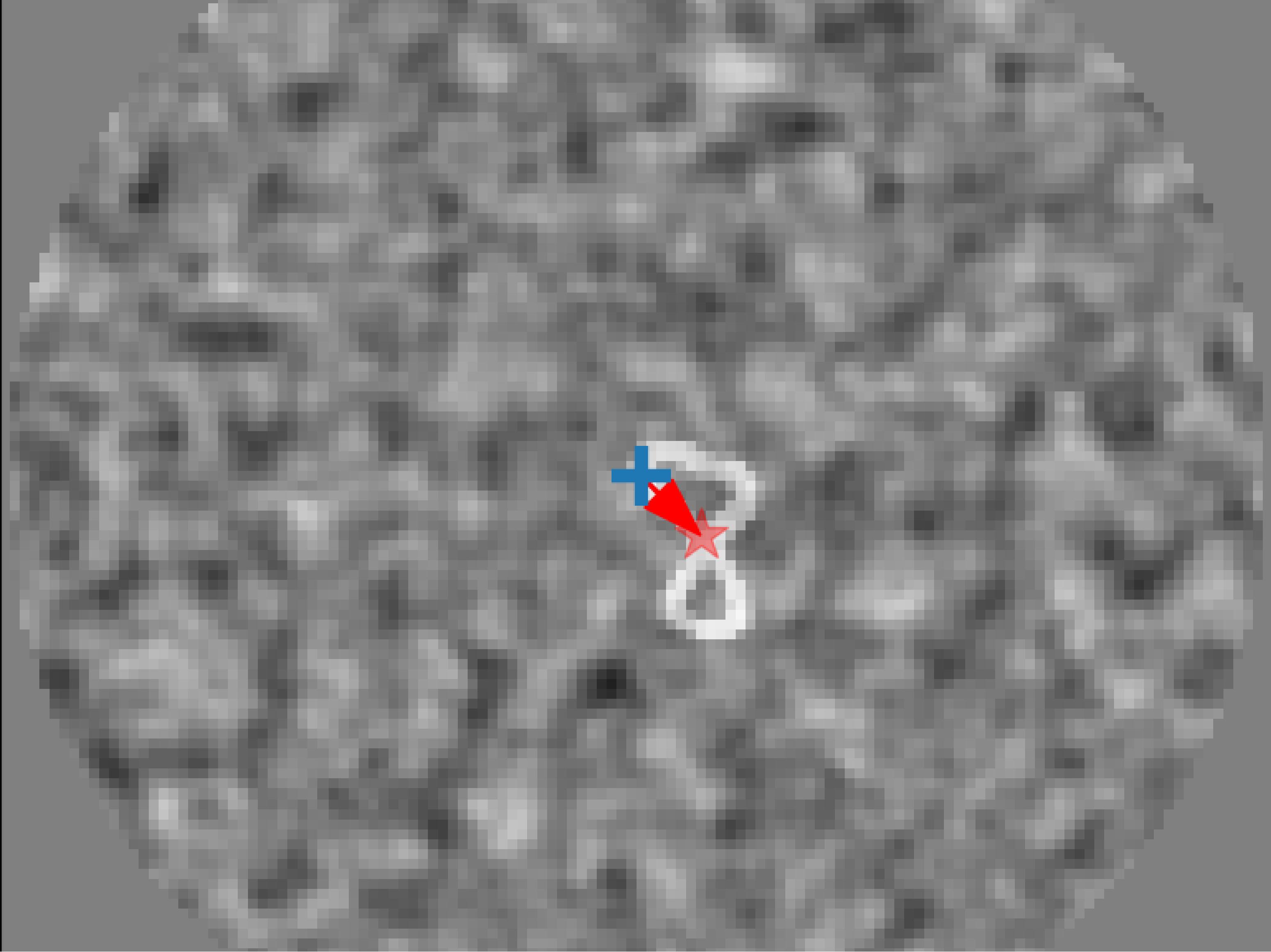




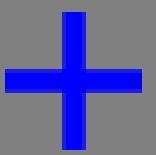
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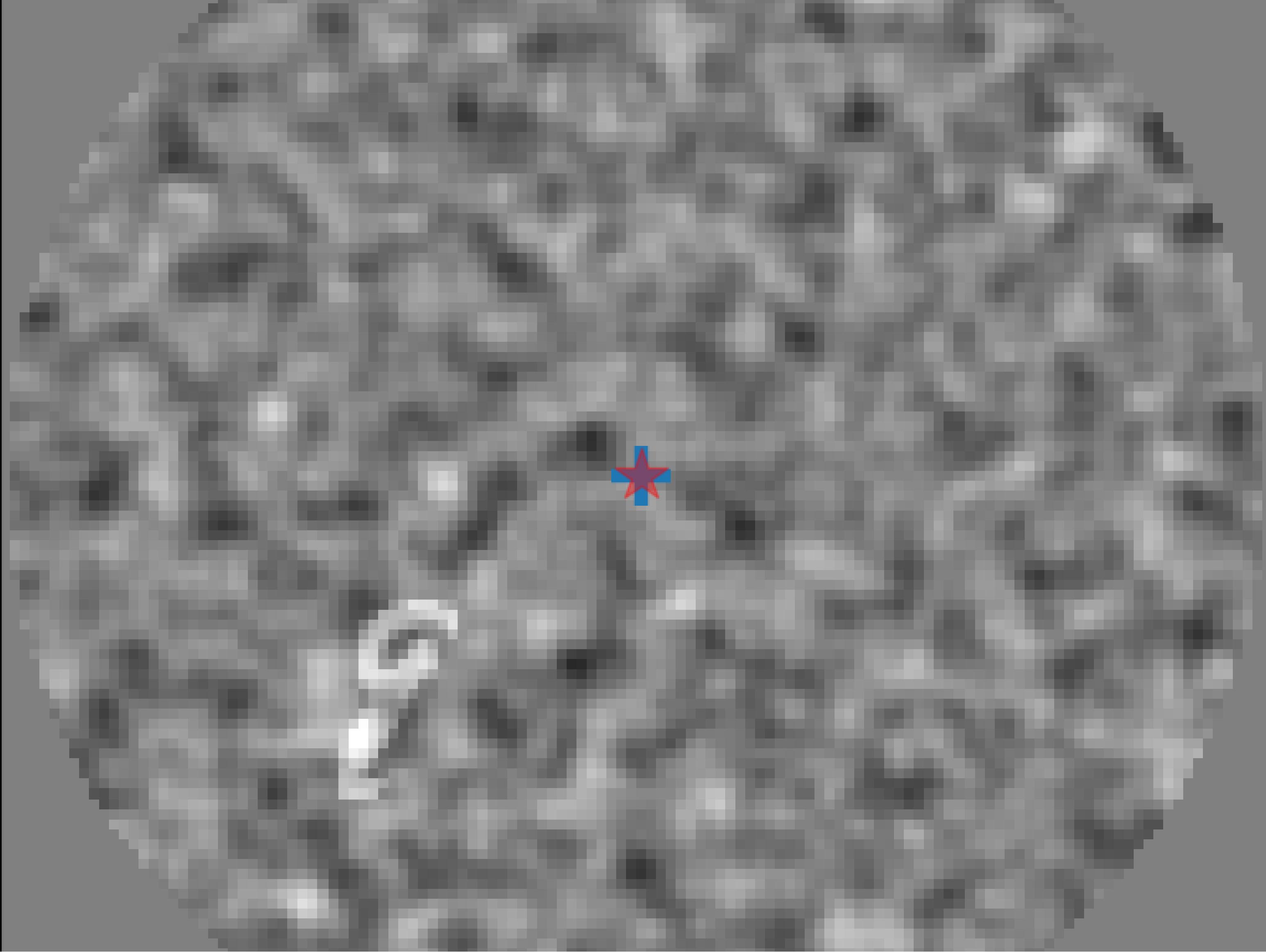


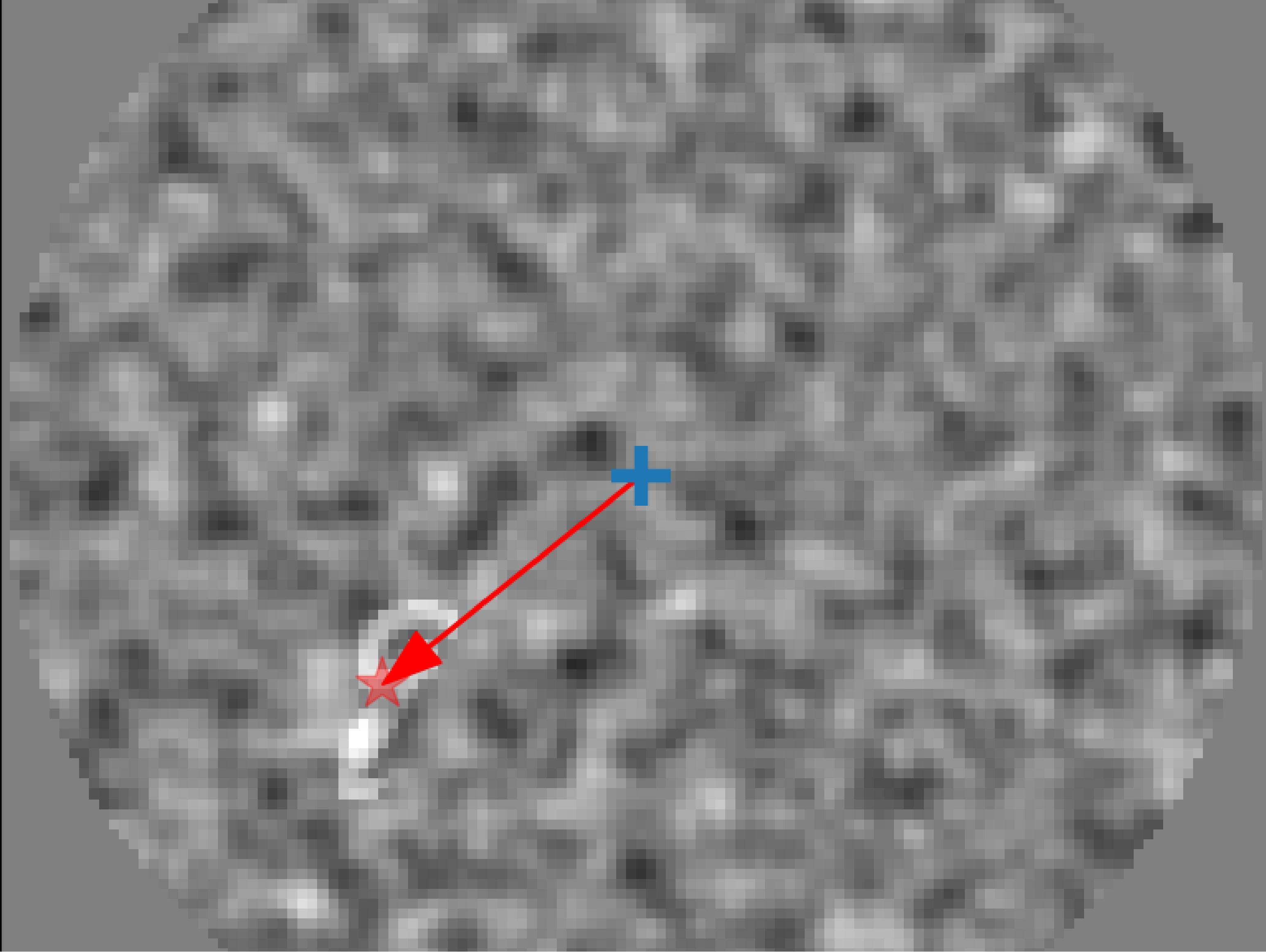




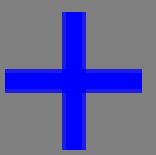
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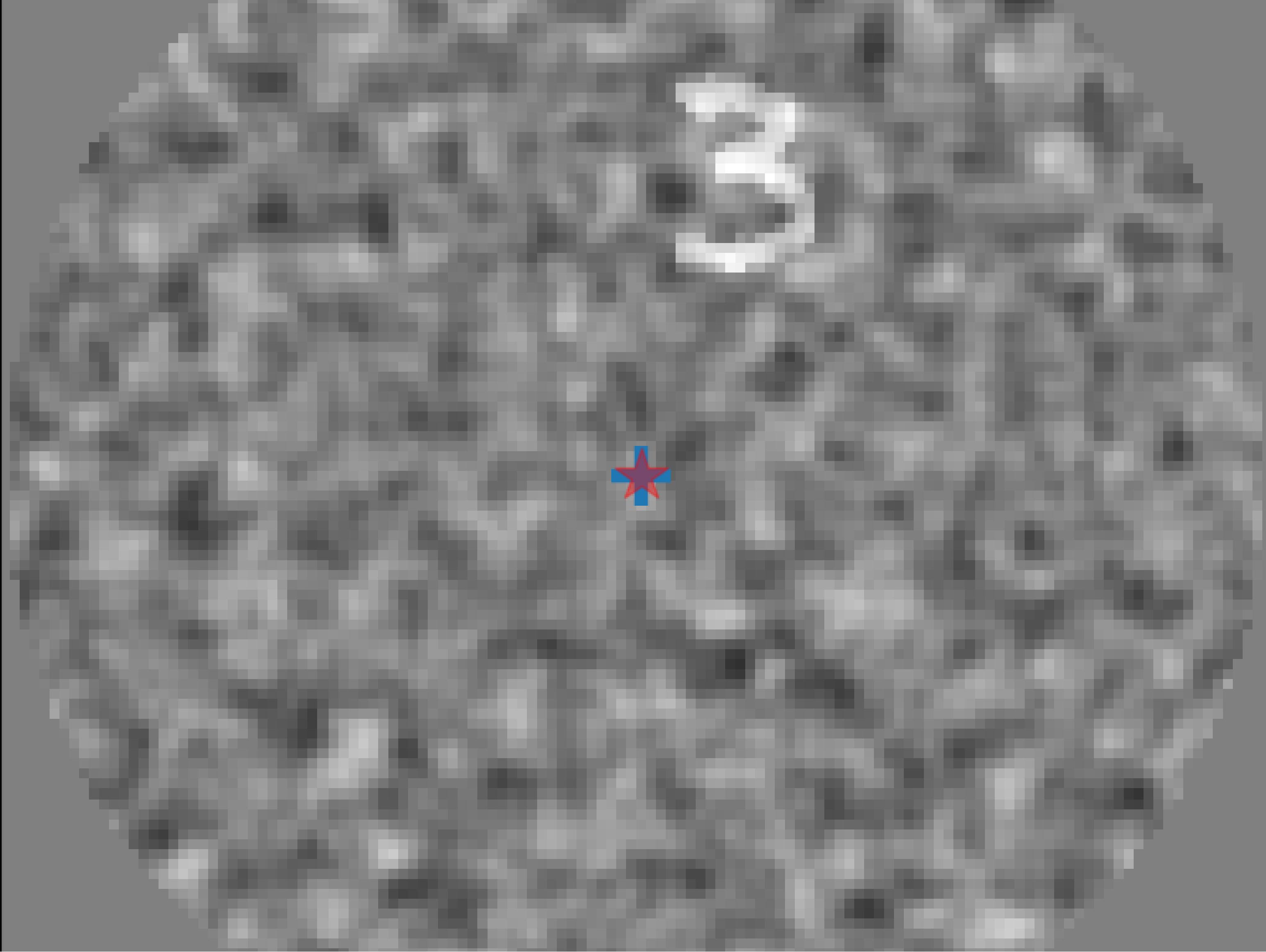


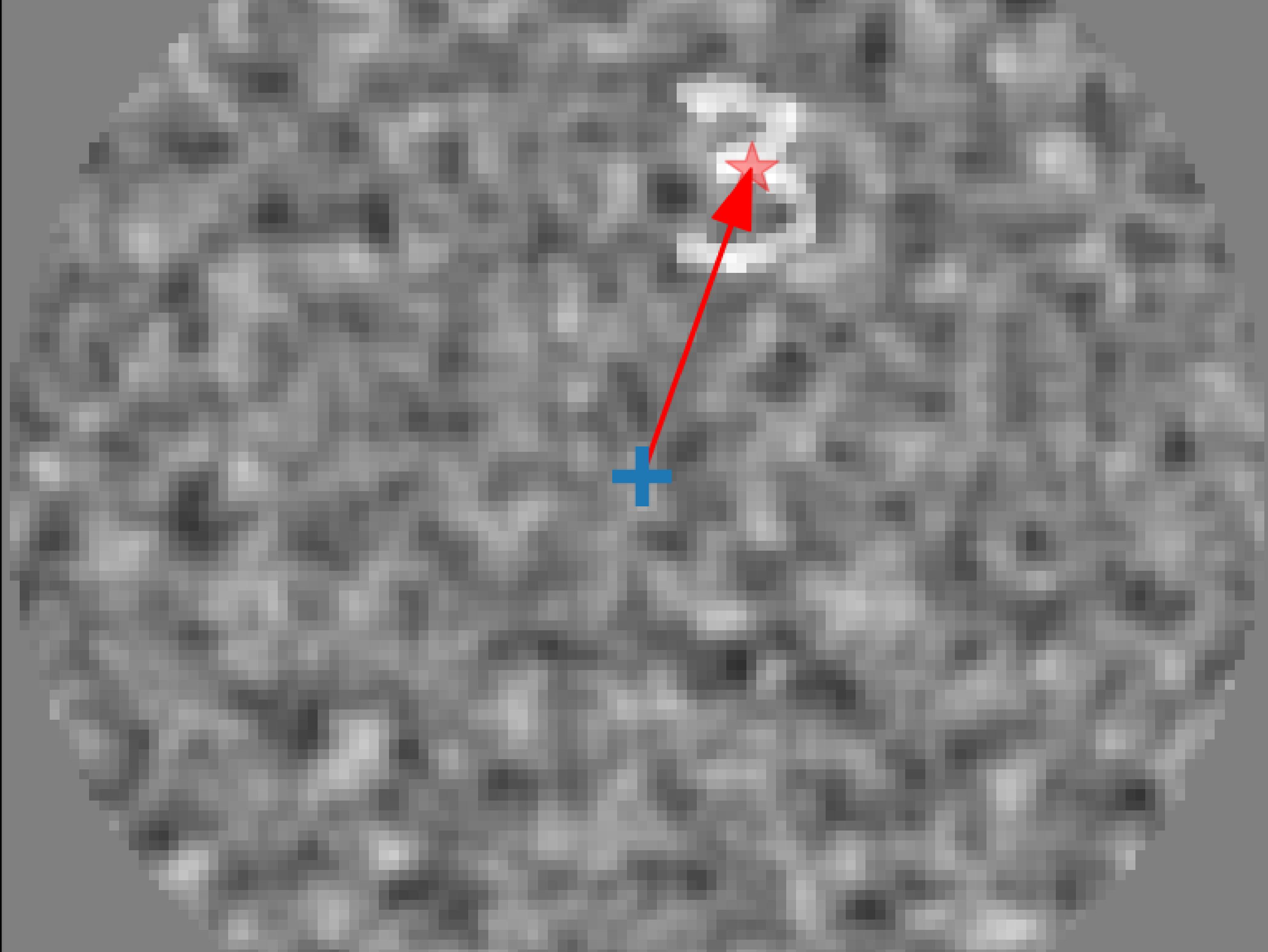




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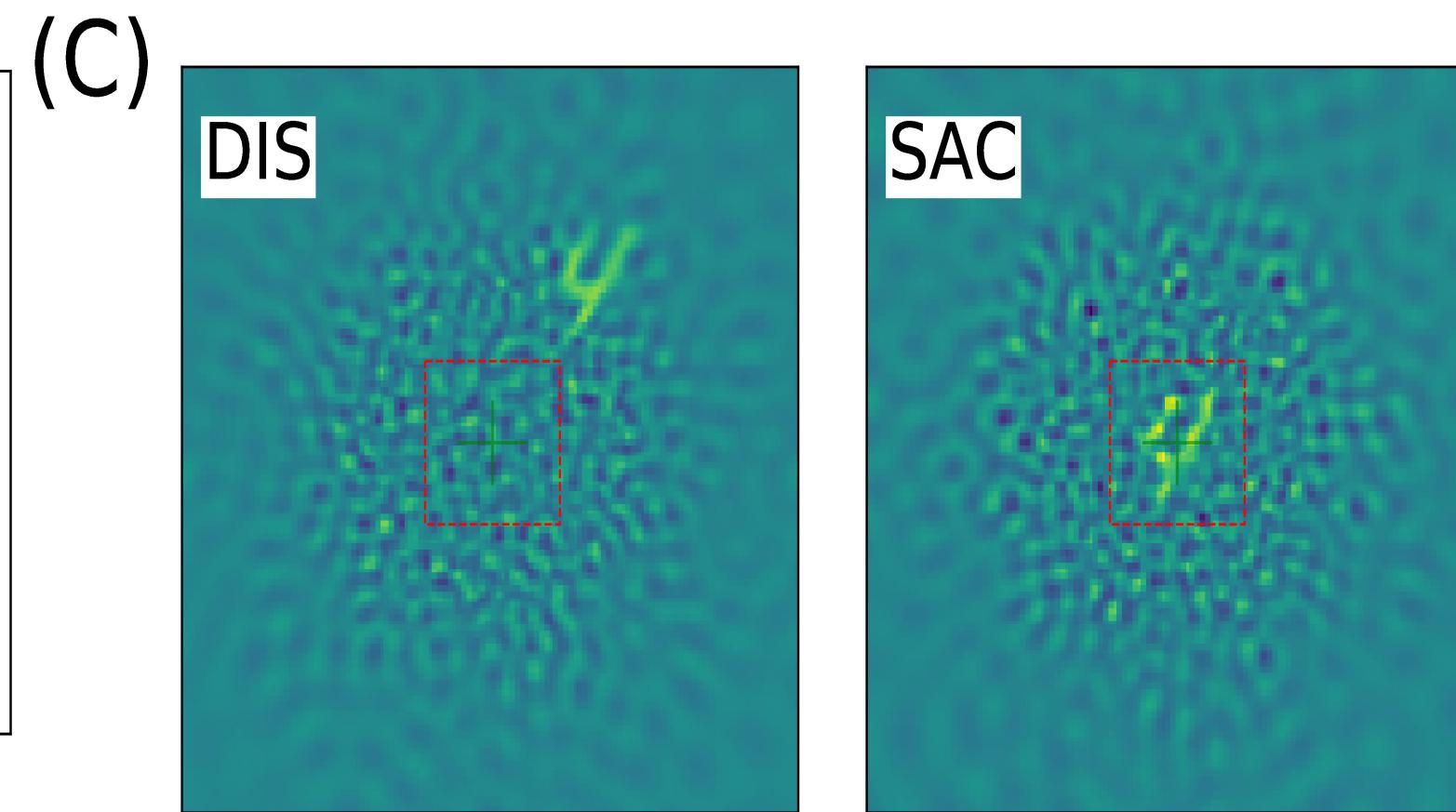
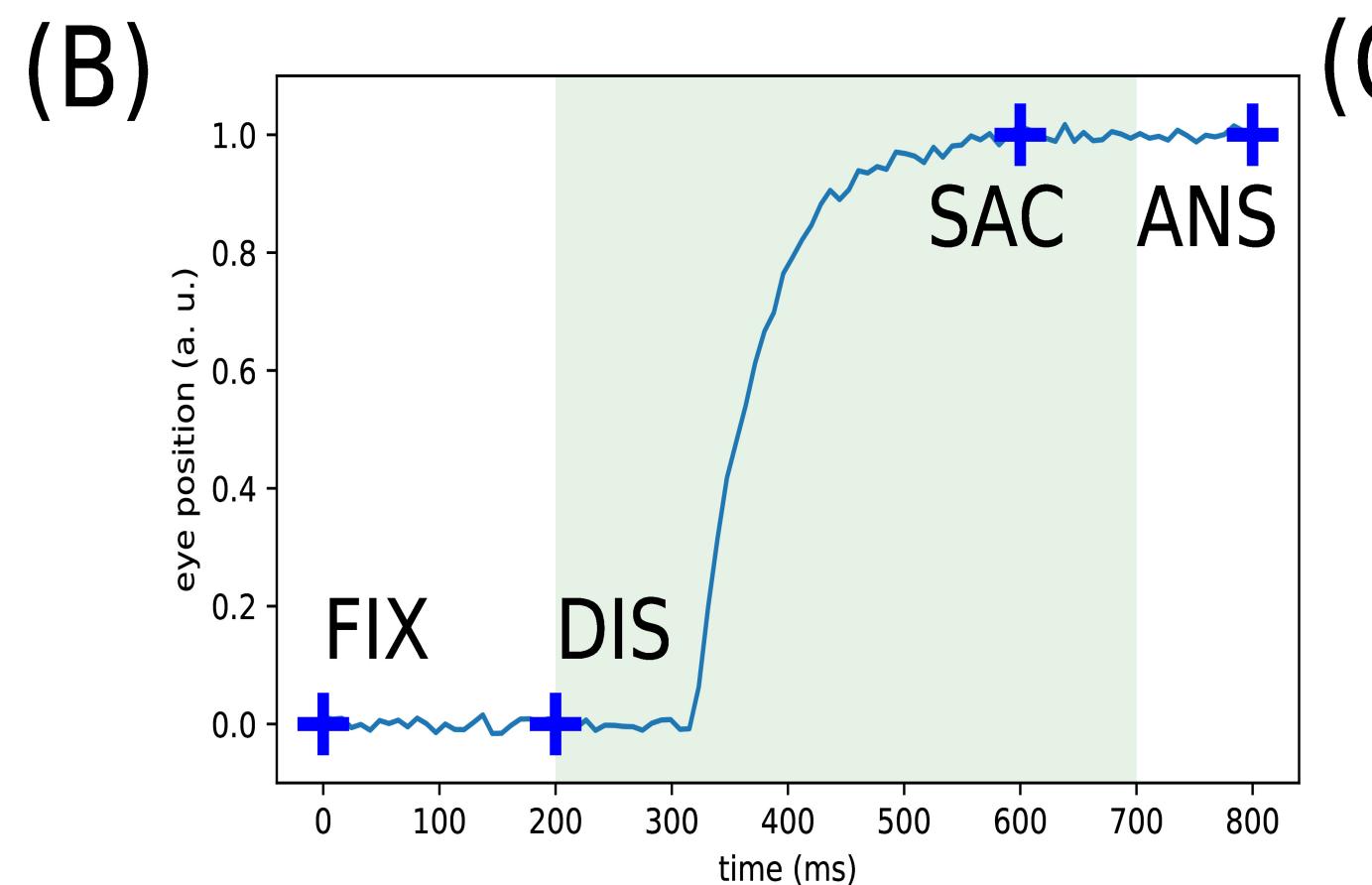
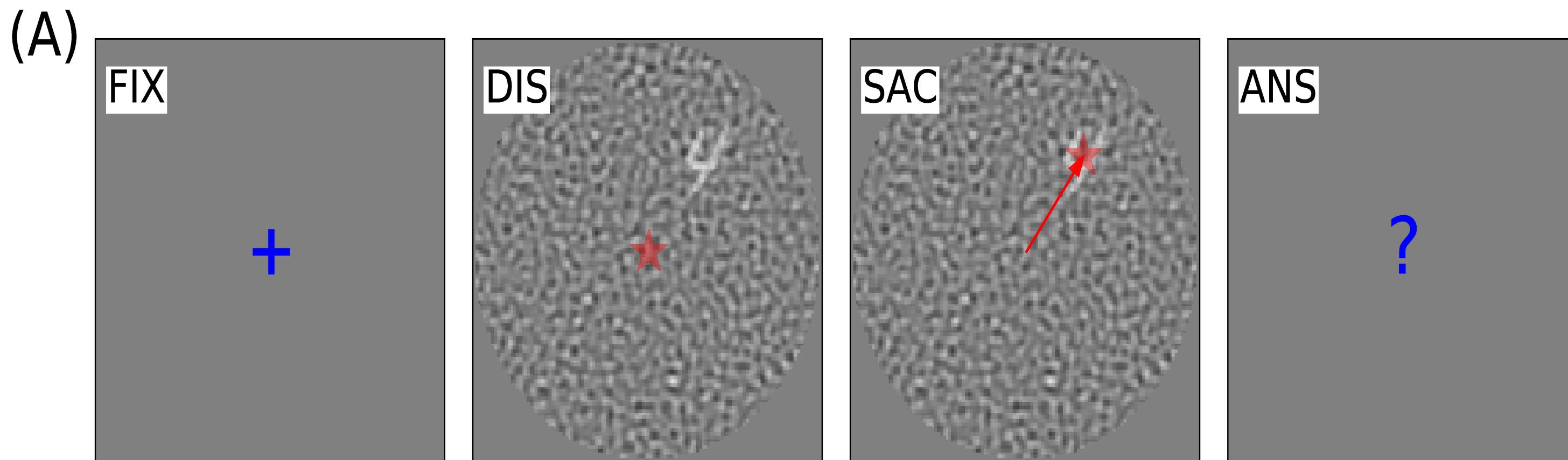




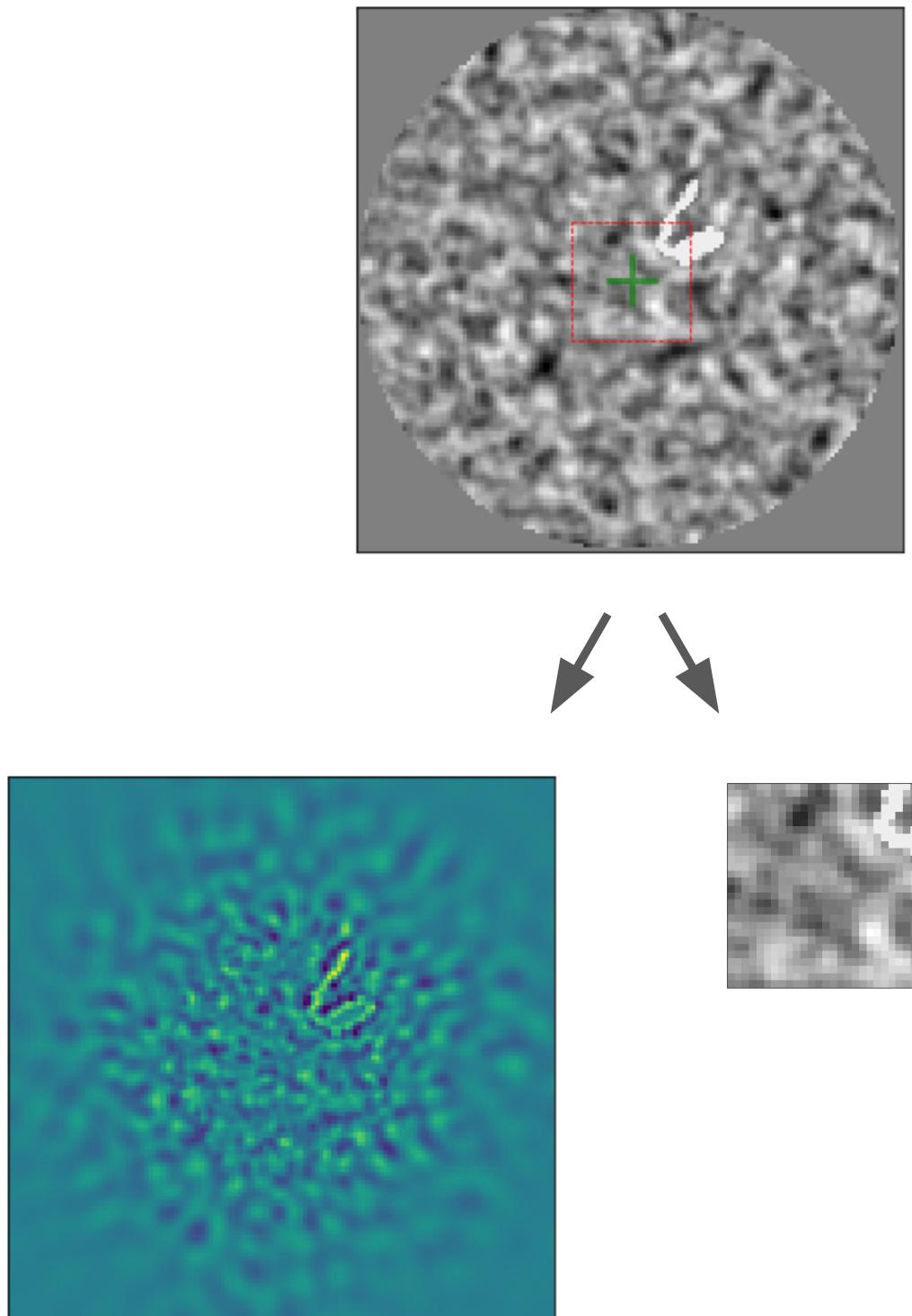


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Methods - "Experimental" setup



Methods: What/Where separation



Approximate Information Gain :

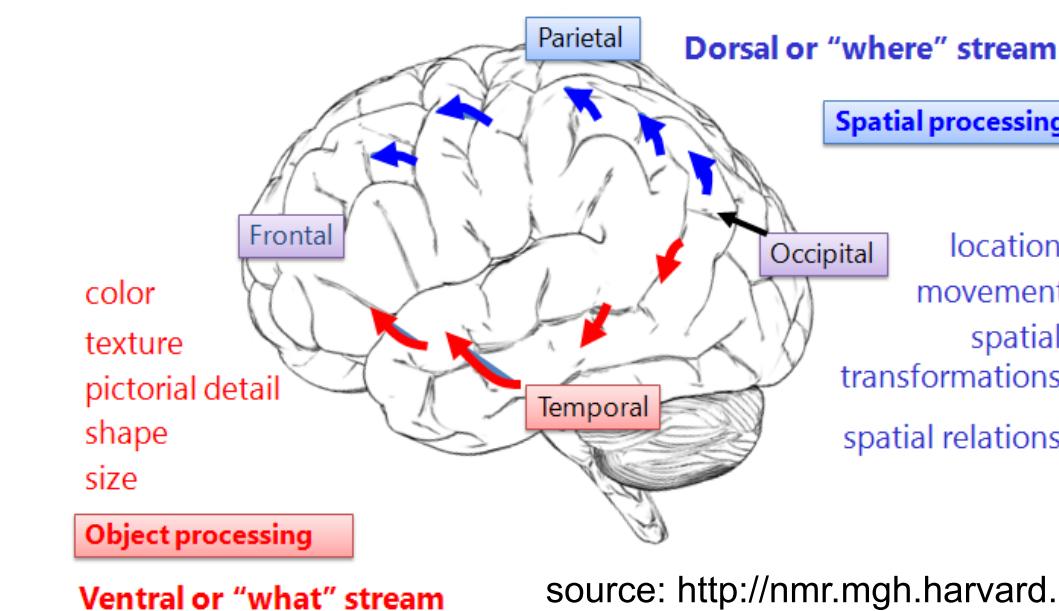
$$E_y [\log P(Y|x, u) - \log P(Y)] \approx$$

$$\log P(\hat{y}|x, u) - \log P(\hat{y})$$

Future Central Accuracy
(after saccade)

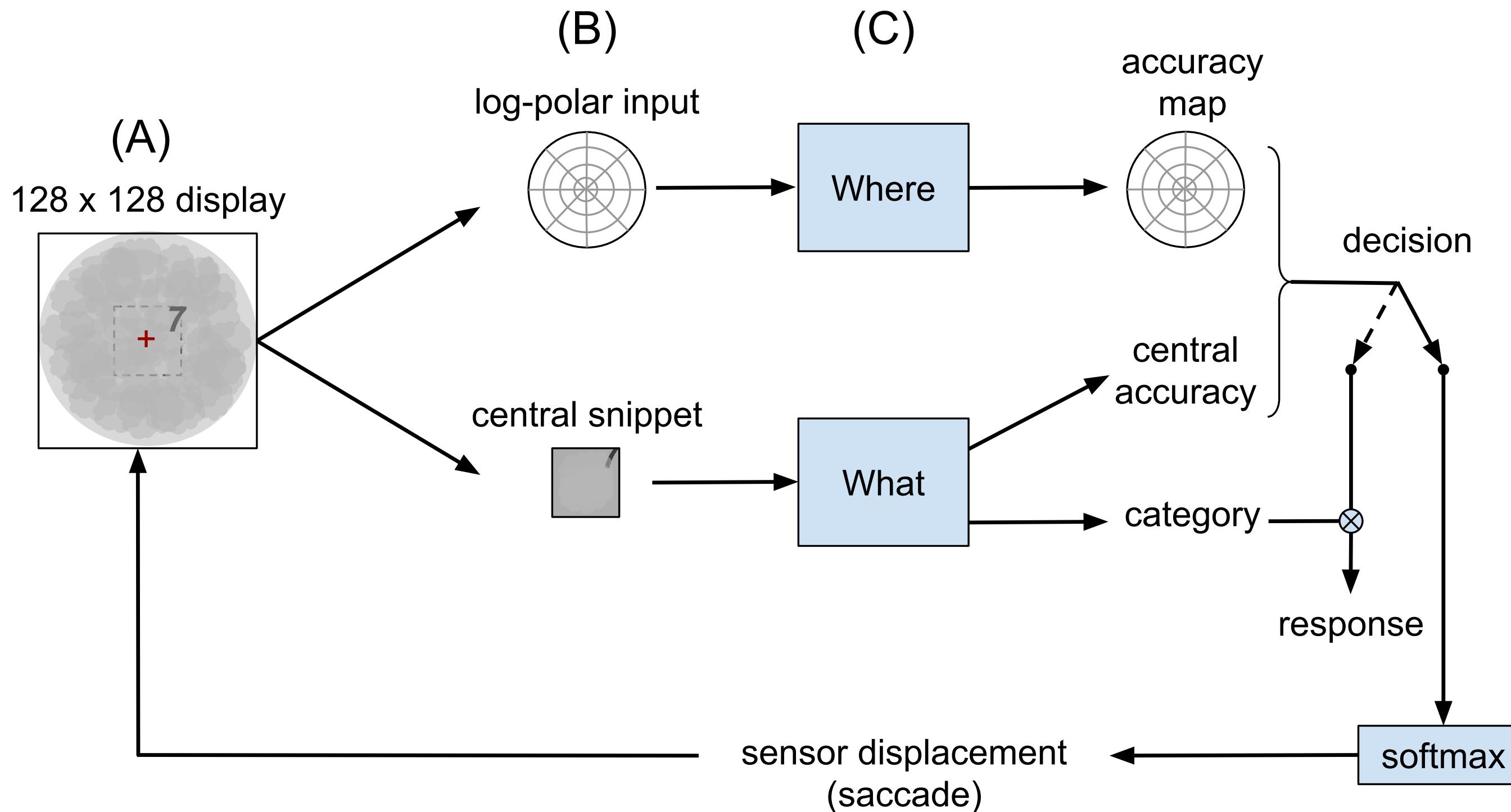
Central Accuracy

What/where pathways in visual processing
Mishkin, M., Ungerleider, L. G., & Macko, K. A. (1983).

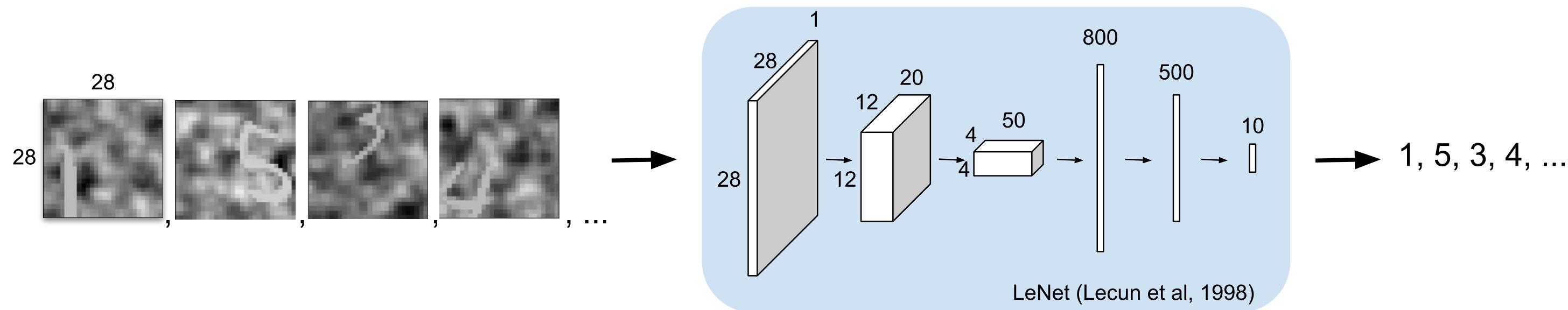


source: <http://nmr.mgh.harvard.edu>

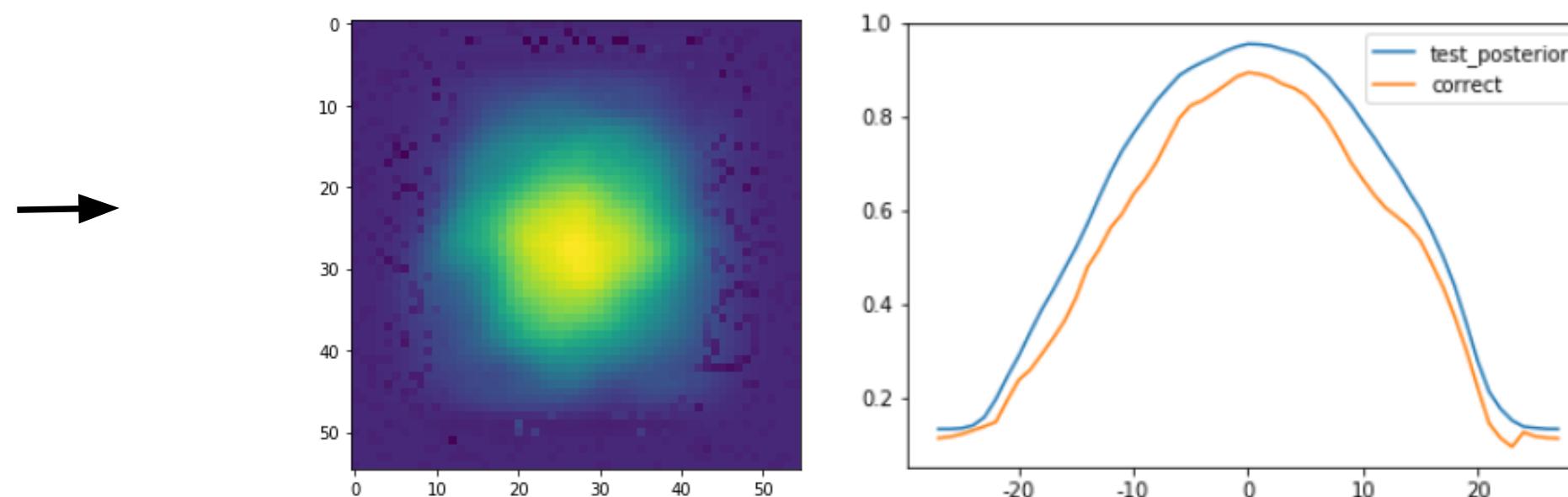
Methods: Computational Graph



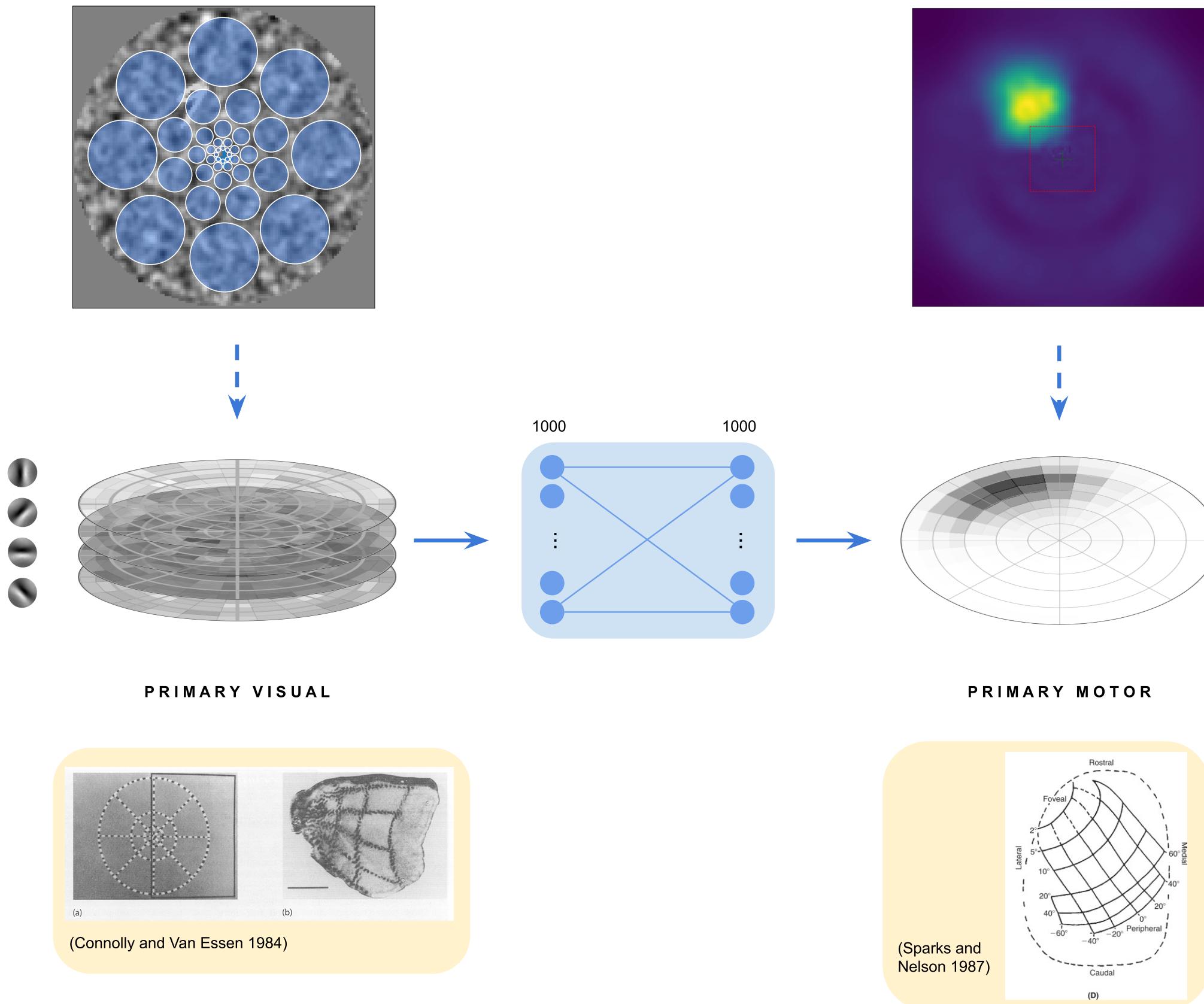
Methods: What



Shift-dependent Accuracy Map



Methods: Where



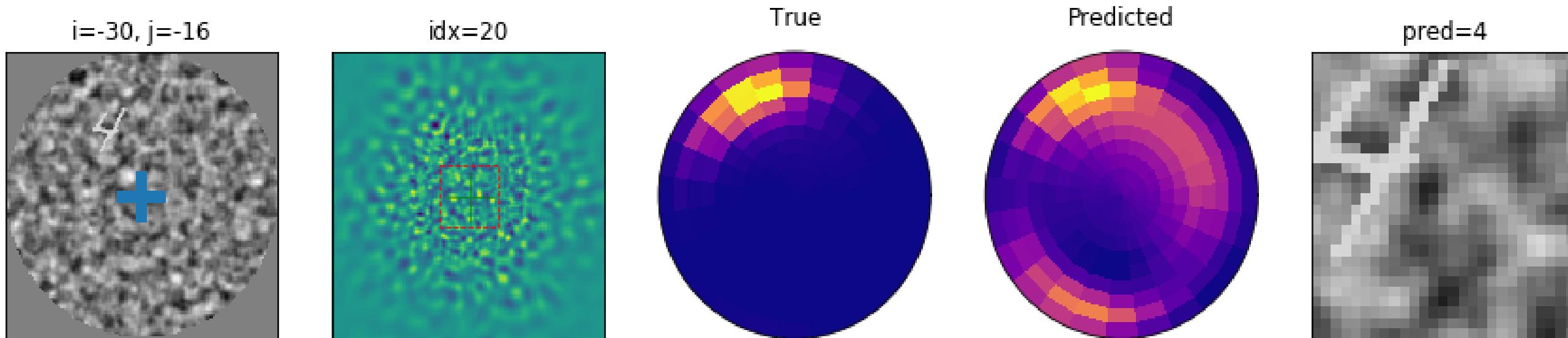
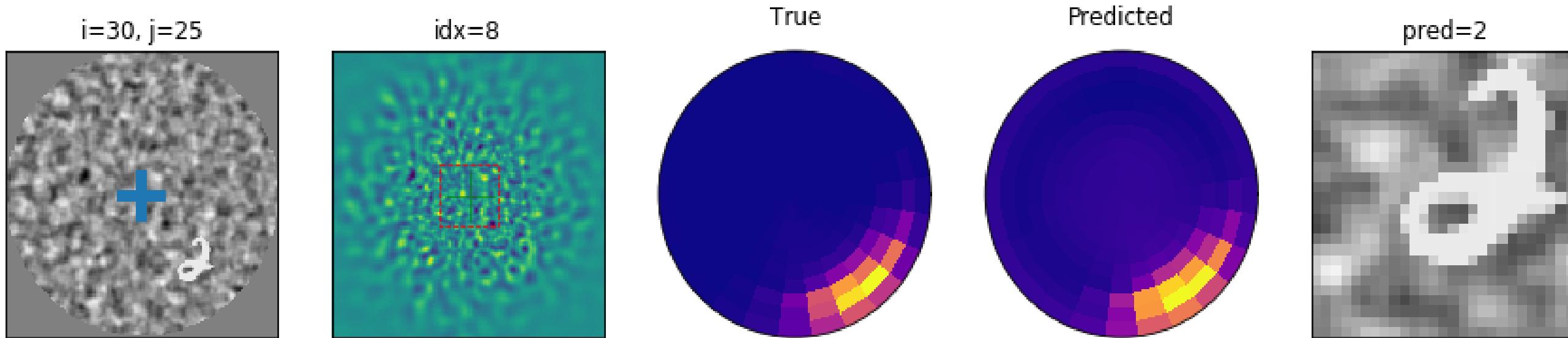
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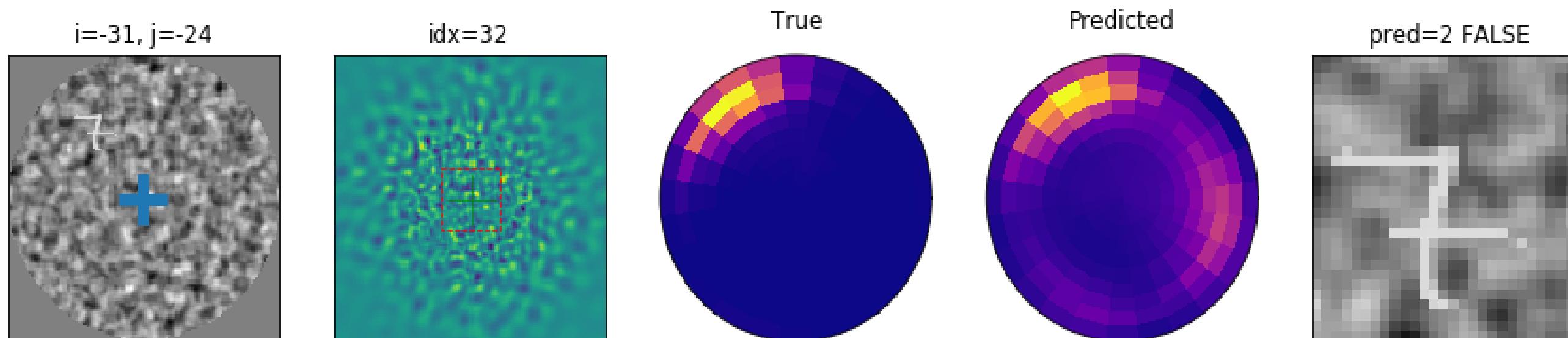
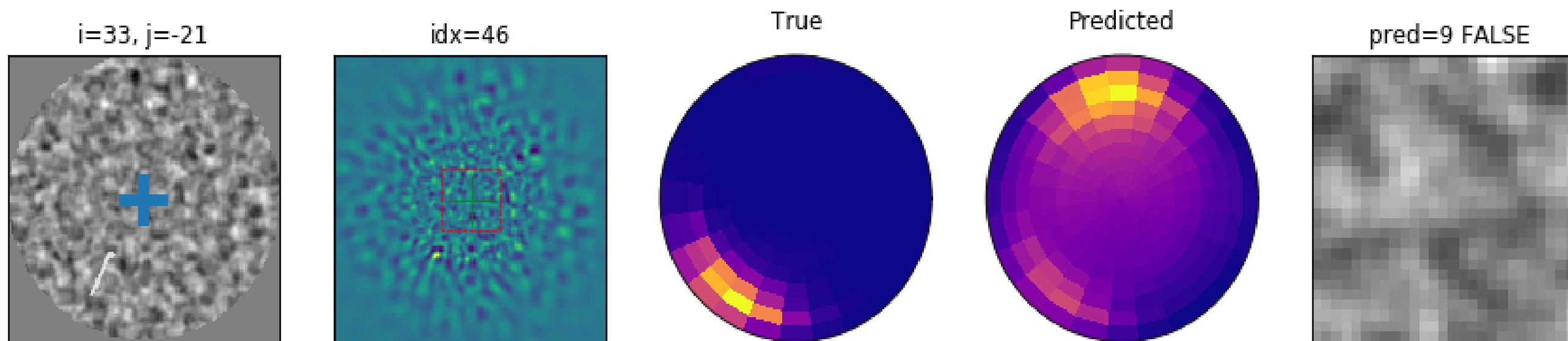
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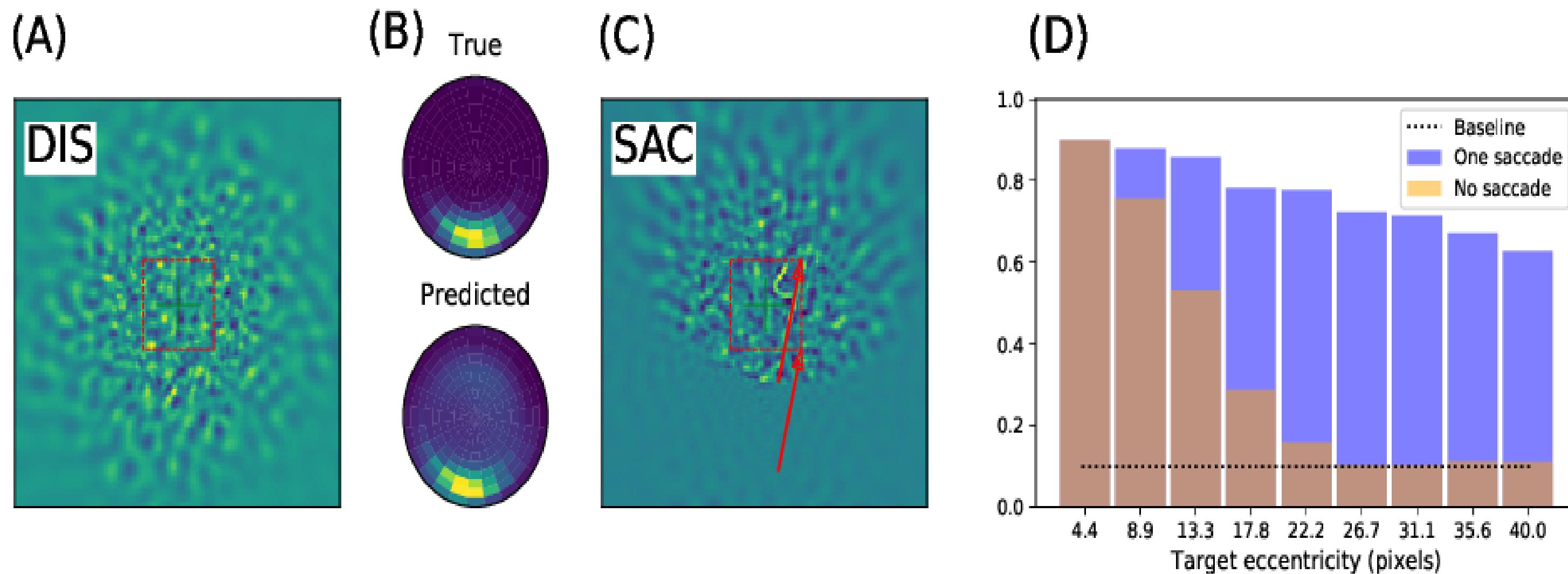
Results: success



Results: failure

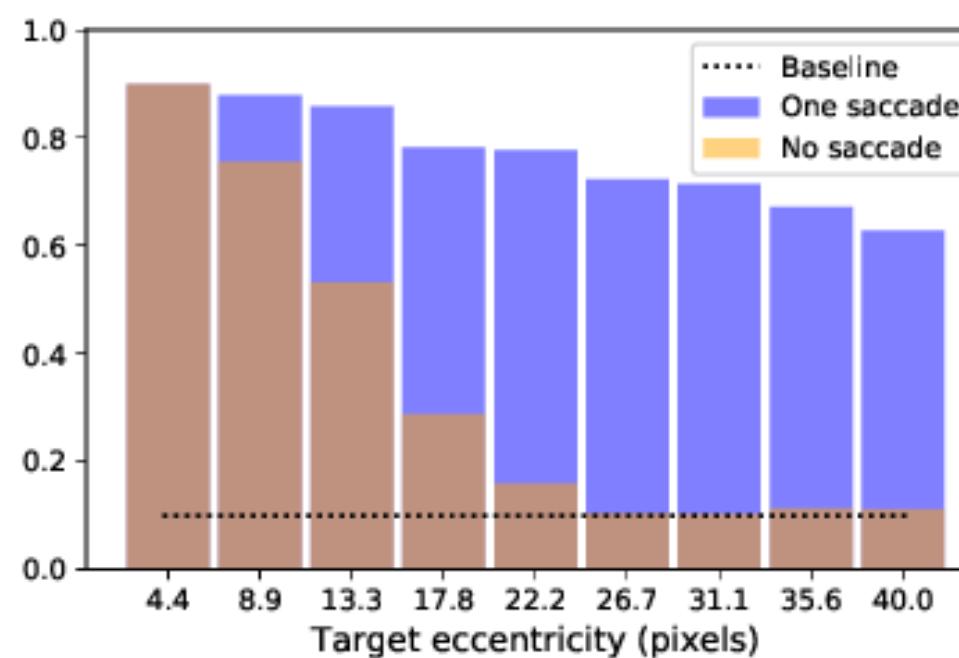


Results: one saccade

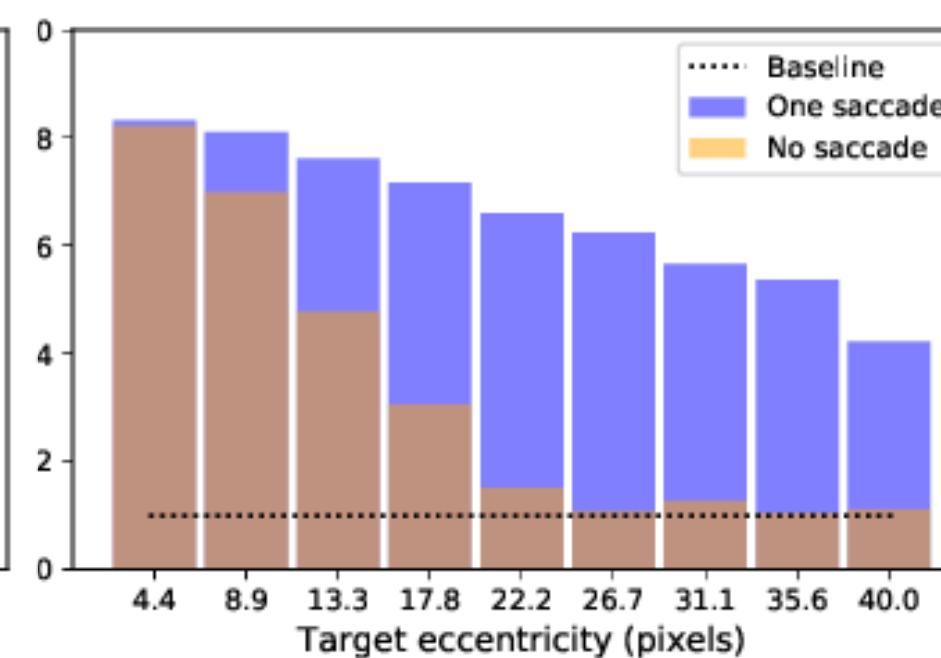


Results: role of contrast

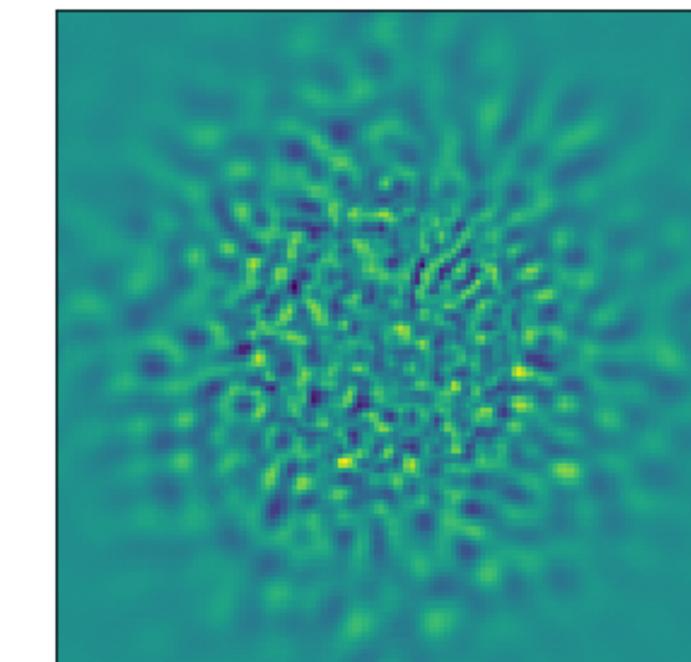
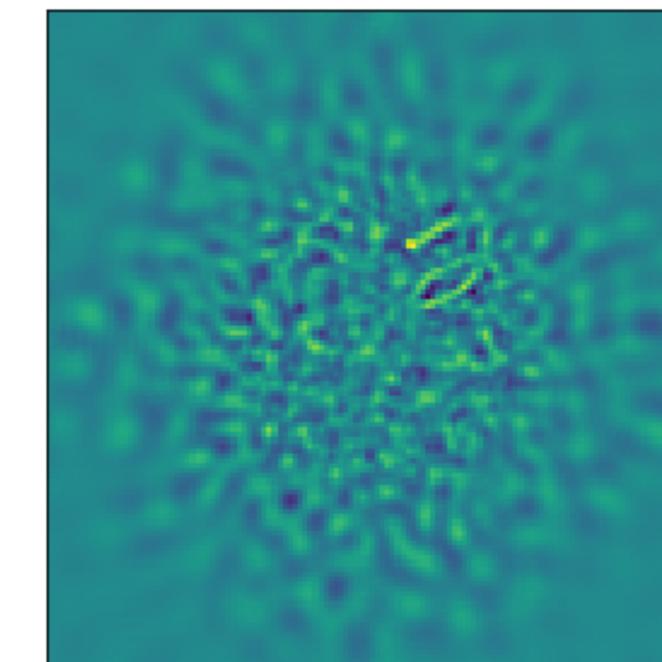
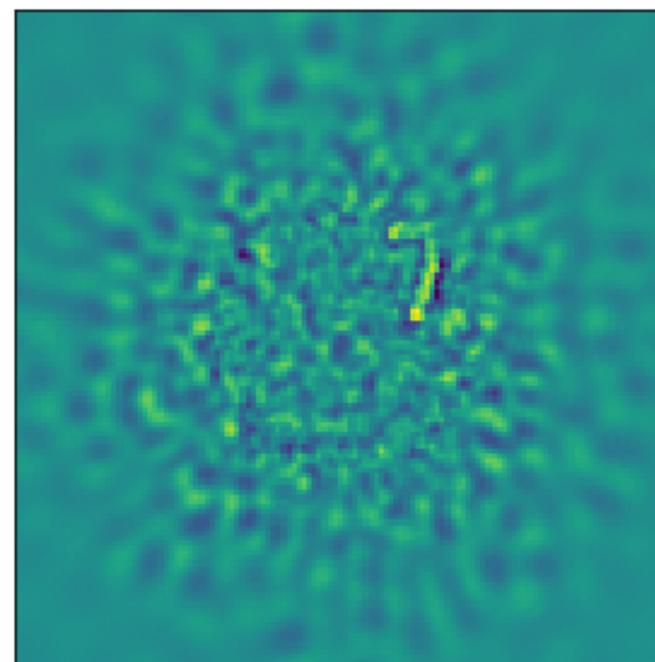
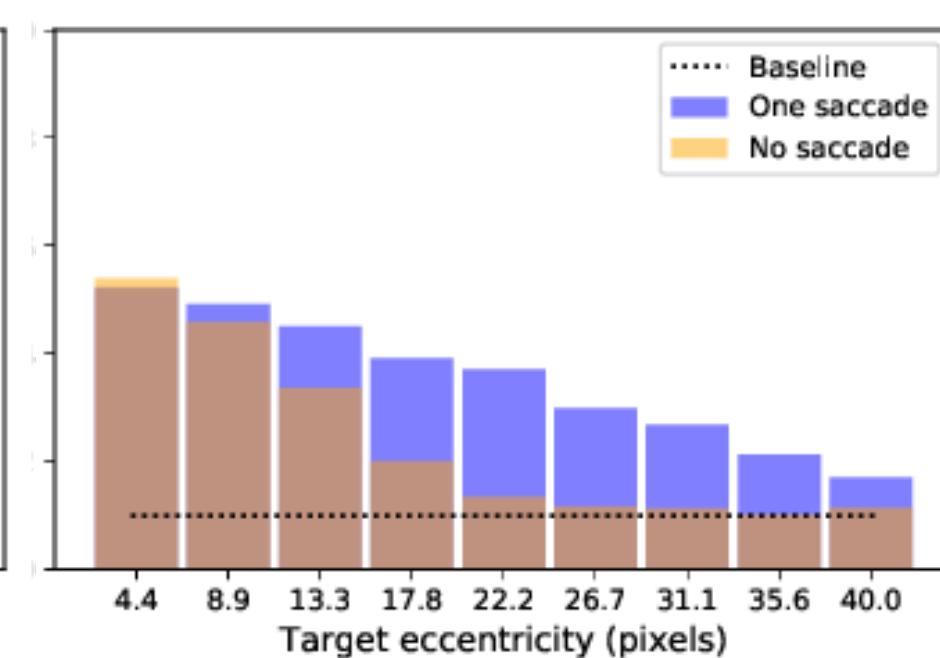
Contrast = 0.7



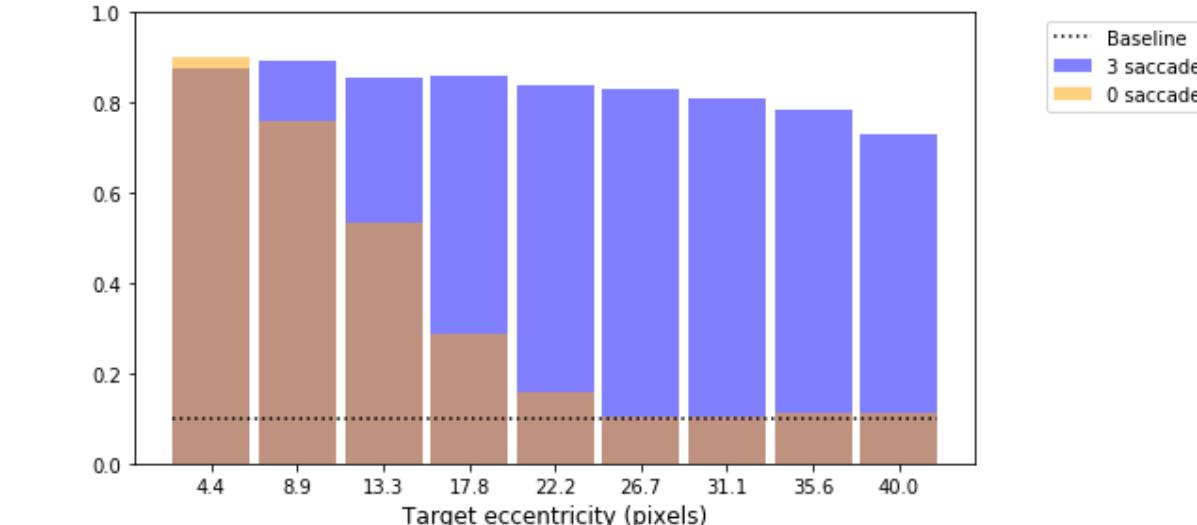
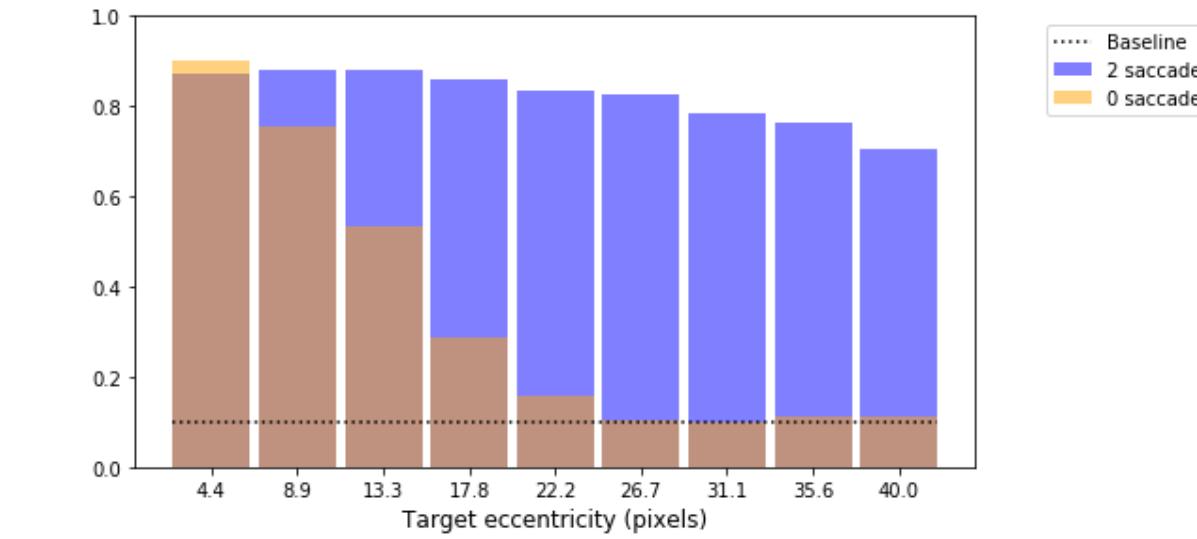
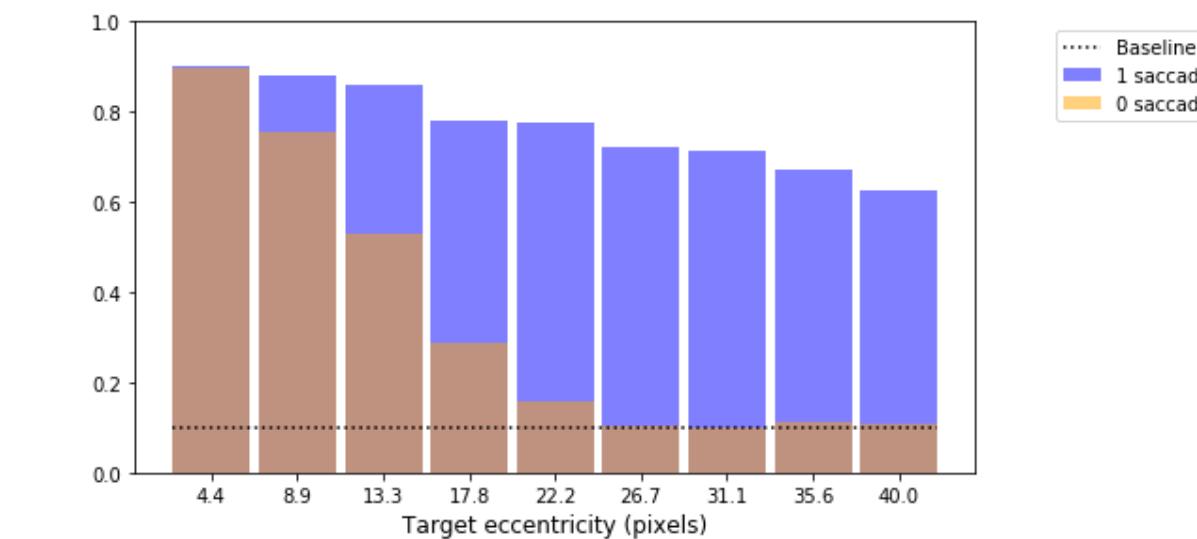
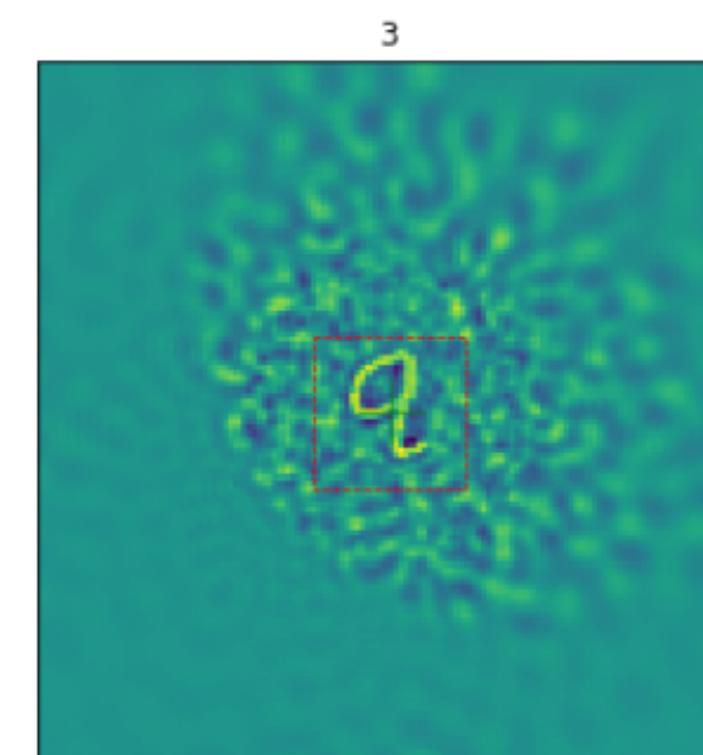
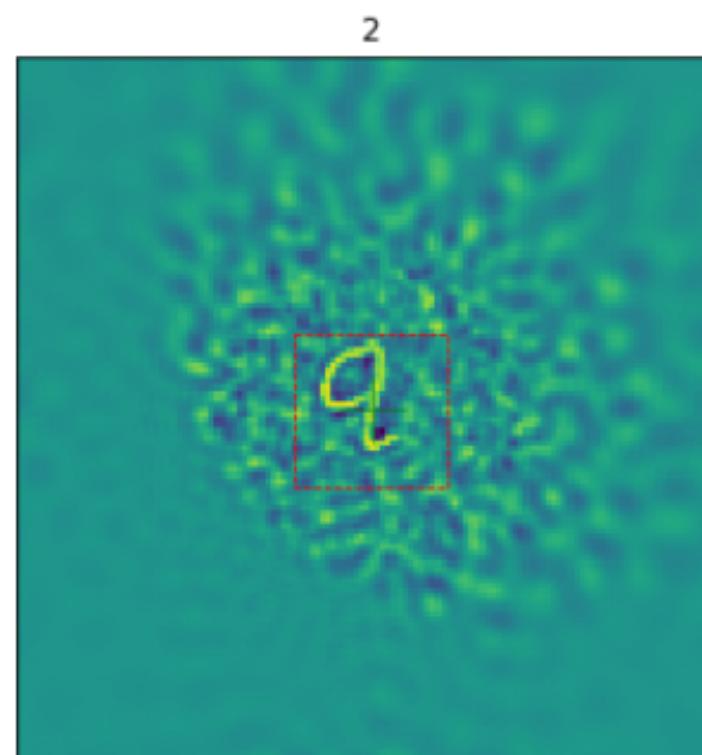
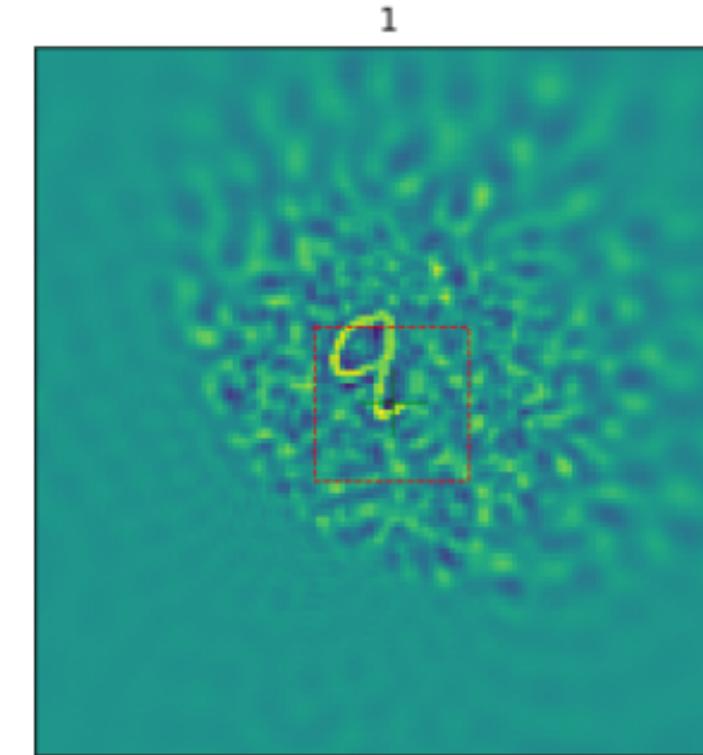
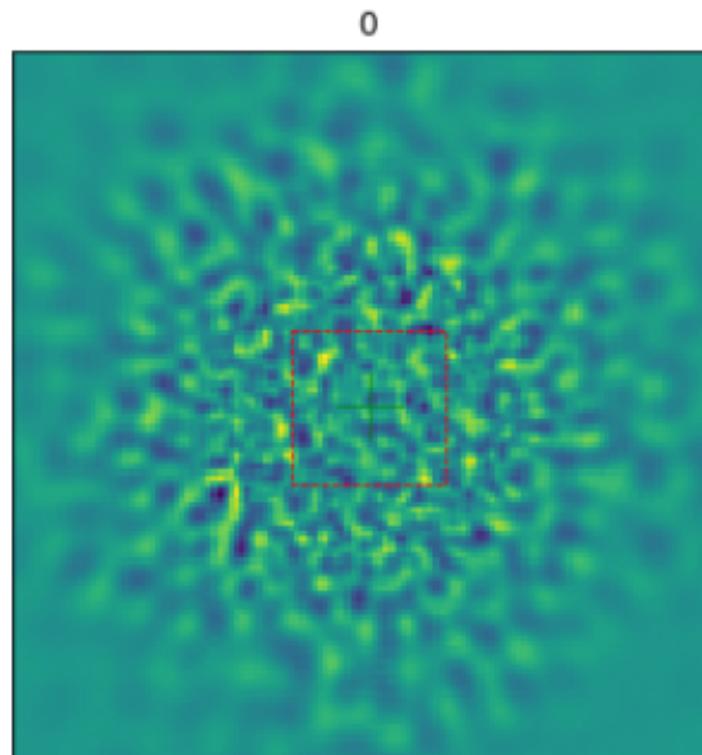
Contrast = 0.5



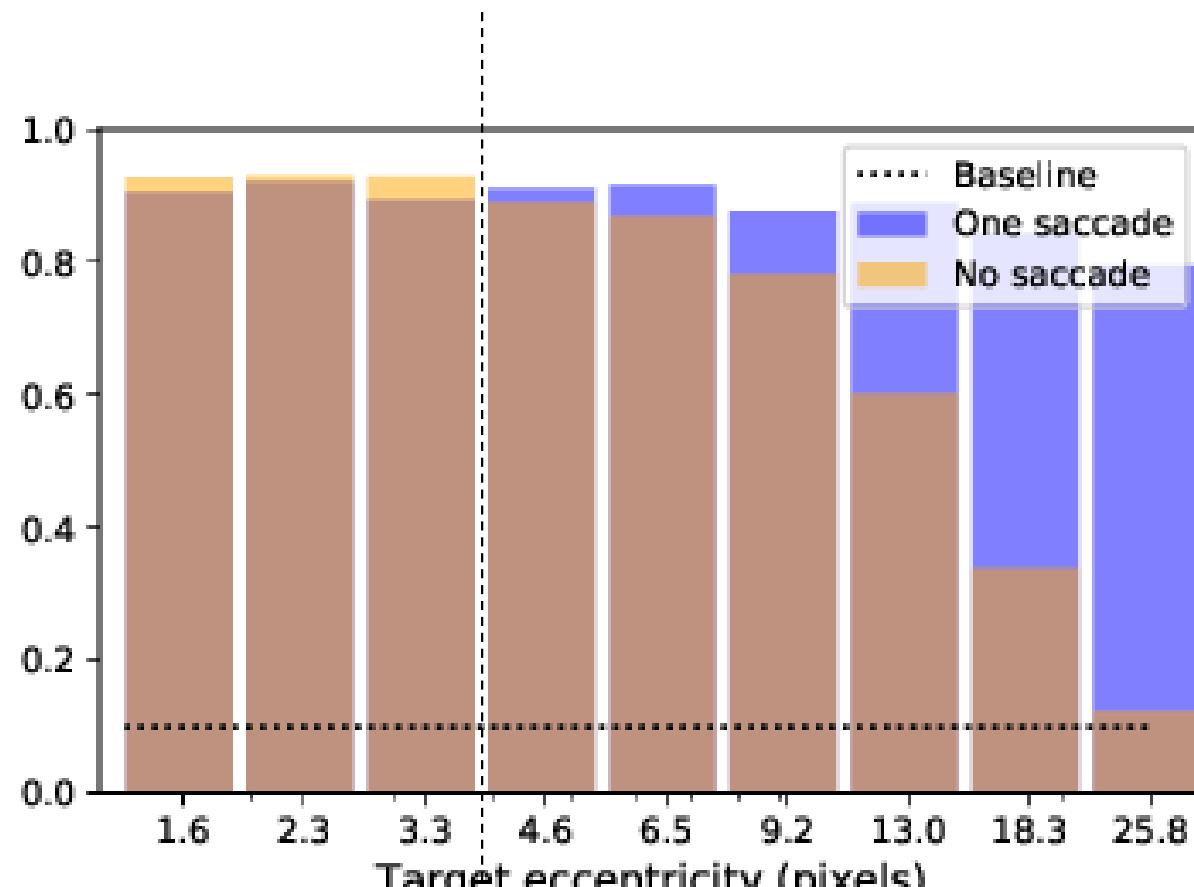
Contrast = 0.3



Results: more saccades



IG-based selection of action



D E C I S I O N B O U N D A R Y

$$\log P(\hat{y}|x, u) - \log P(\hat{y})$$

Future Central
Accuracy
(after saccade)

Central Accuracy

Main results

- A new interpretation of Information Gain in visuo-motor action selection :
 - Center-surround interpretation
 - An effective decoding scheme with strong bandwidth reduction
 - Information-gain based selection of action (saccade/pursuit)
- Object identity-based monitoring of action
 - Dorsal = "actor" (where to look next?)
 - Ventral = "critic" (for what to see?)

Limits and Open questions

- centering / log polar
- IG décision : fixation/following or saccade. After some Time the info gain is zéro: it is not interesting any more to issue a saccade regarding this particular target.
- multi - targets? Maximizing info gain on multiple targets/ddls. Illustration with z1, z2 axis
- overt/covert attention
- free energy extension? Combination of info gain and predictive coding. 1. Maximize predicted info gain. 2. Read data. 3. Optimize predictive coding.

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