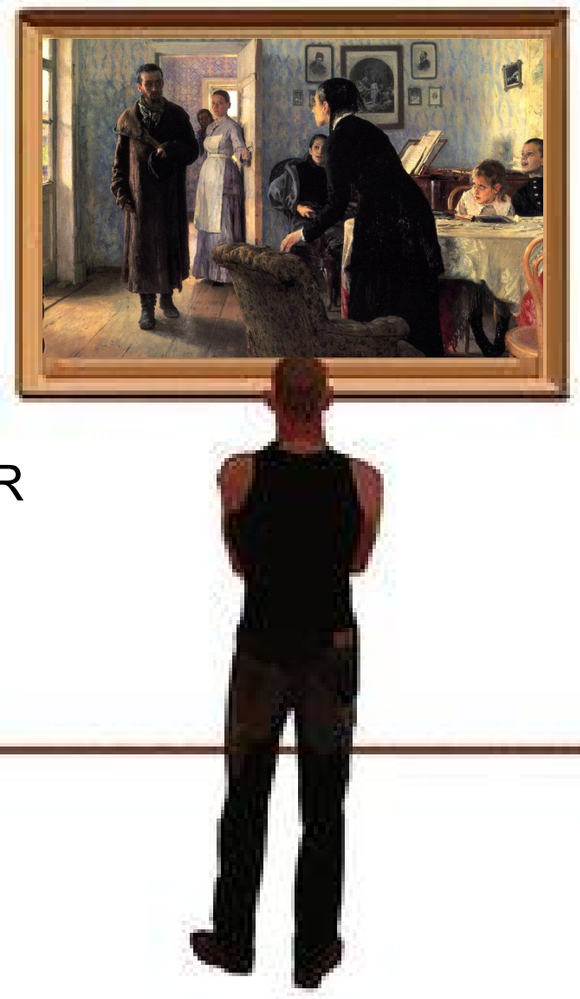
Visual search as active inference

Emmanuel Daucé & Laurent Perrinet

1st International Workshop on Active Inference (IWAI*2020), 14/9/2020

Visual search as active inference

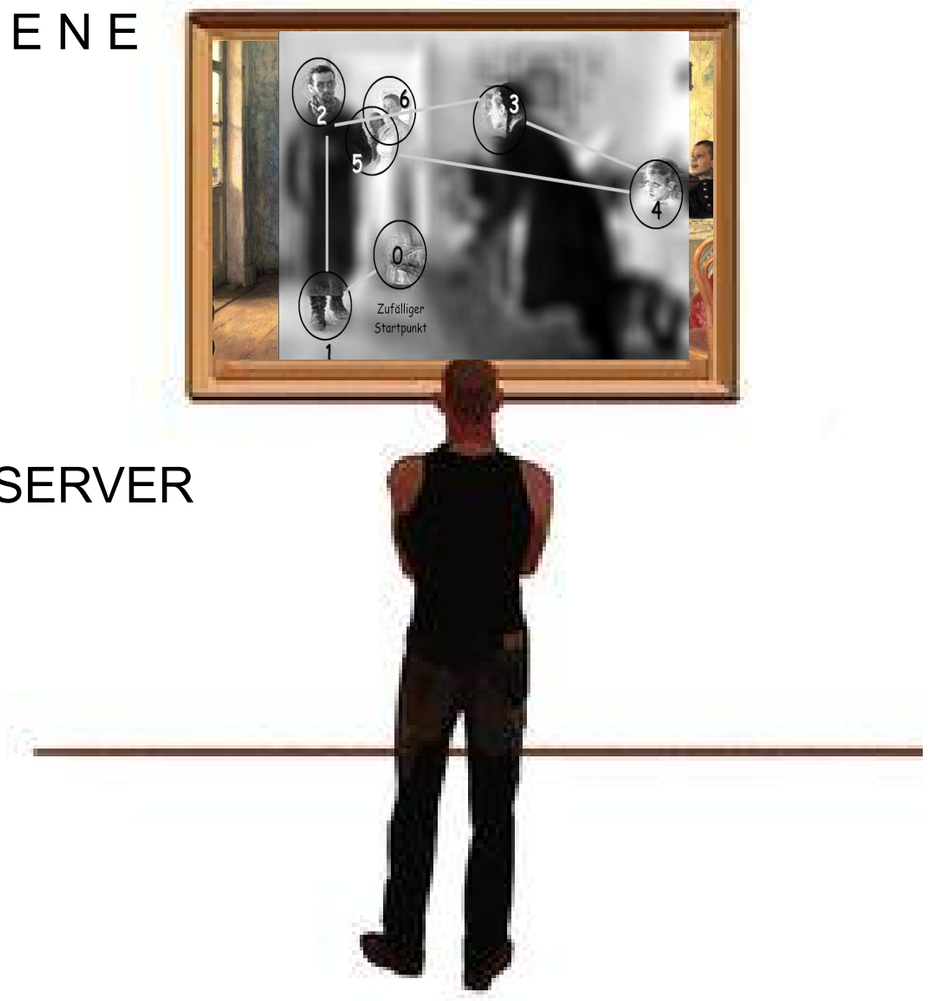
SCENE



OBSERVER

Visual search as active inference

SCENE



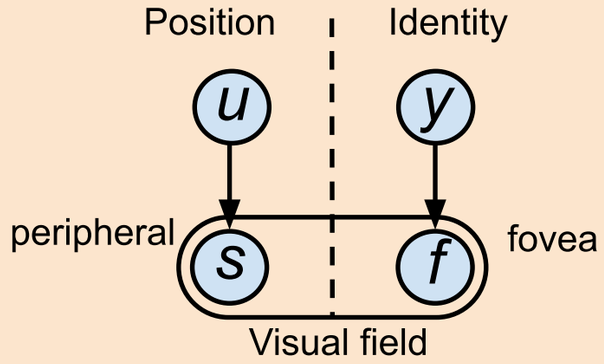
OBSERVER

Visual search as active inference

SCENE

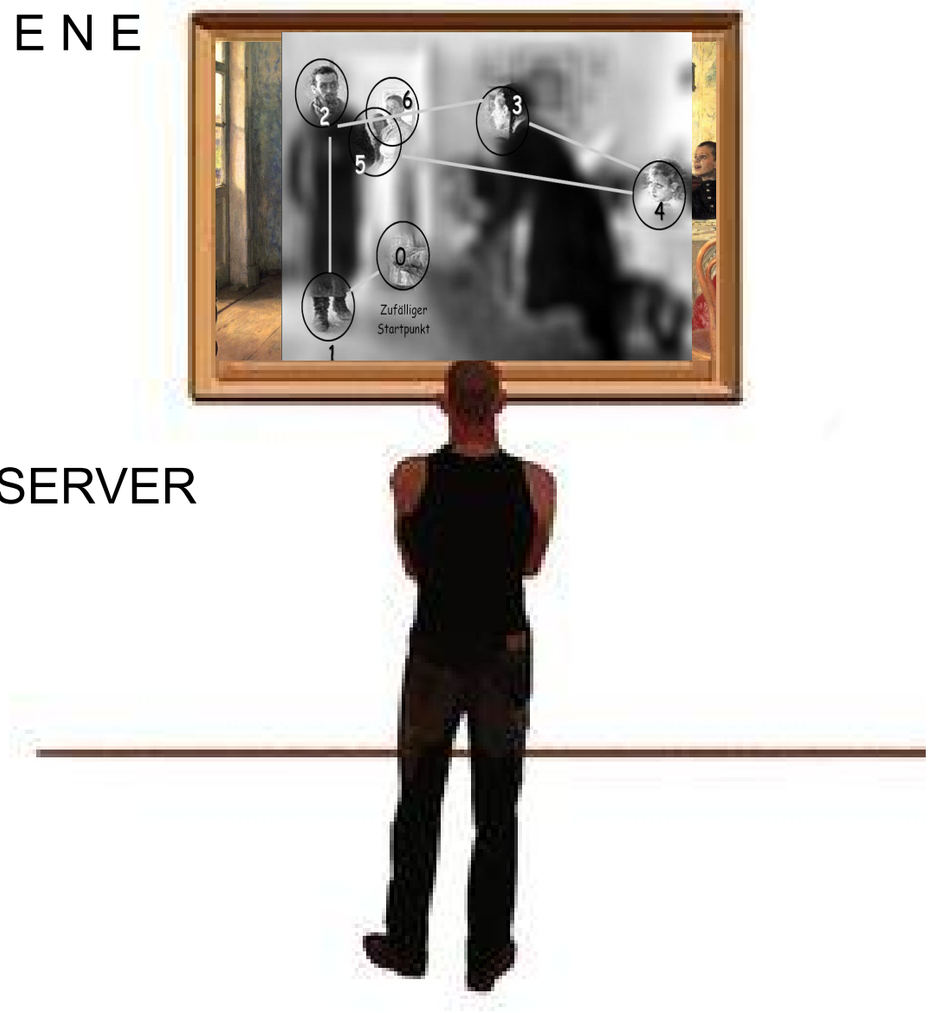
OBSERVER

Generative model



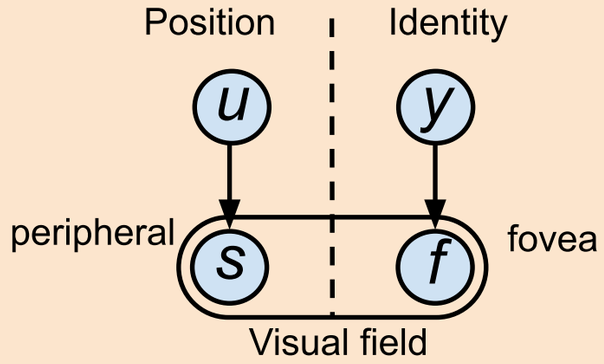
Visual search as active inference

SCENE



OBSERVER

Generative model



Information gain

$$\max_a \mathrm{E}_y \log P(y|f(a)) - \log P(y|f_0)$$

Peripheral processing

Central processing

PREDICTED

CURRENT

Outline

1. Motivation
2. Methods
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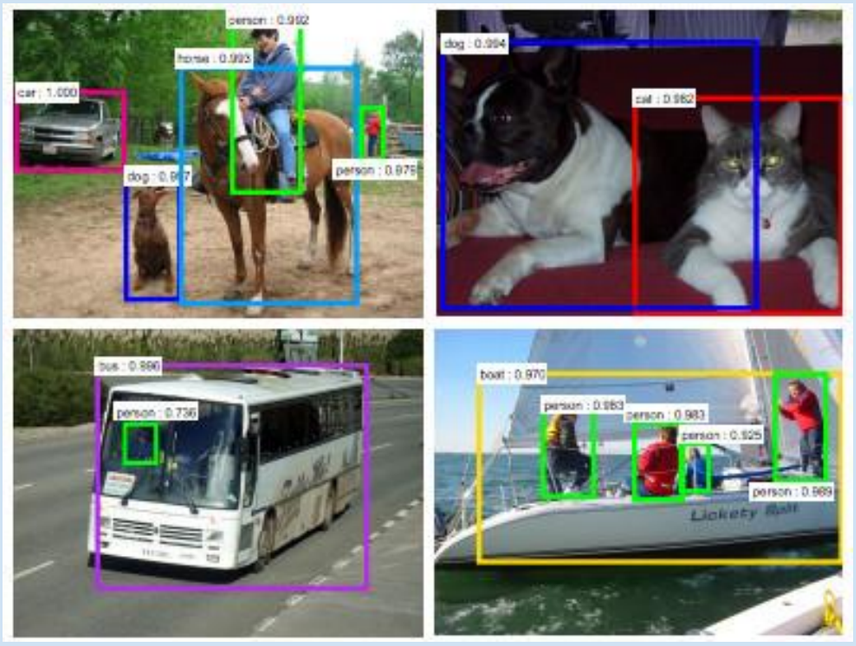
Computer vision

COMPUTER VISION



(Girshick et al, 2015)

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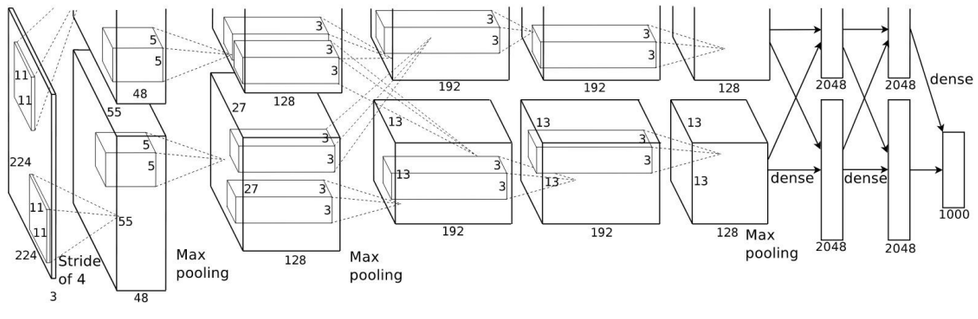
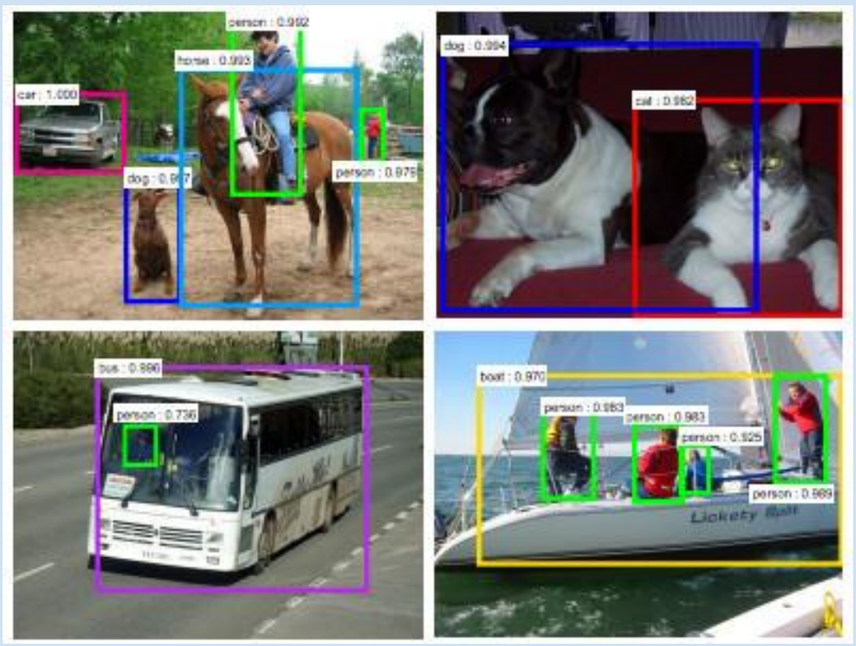


(Hinton et al, 2012)

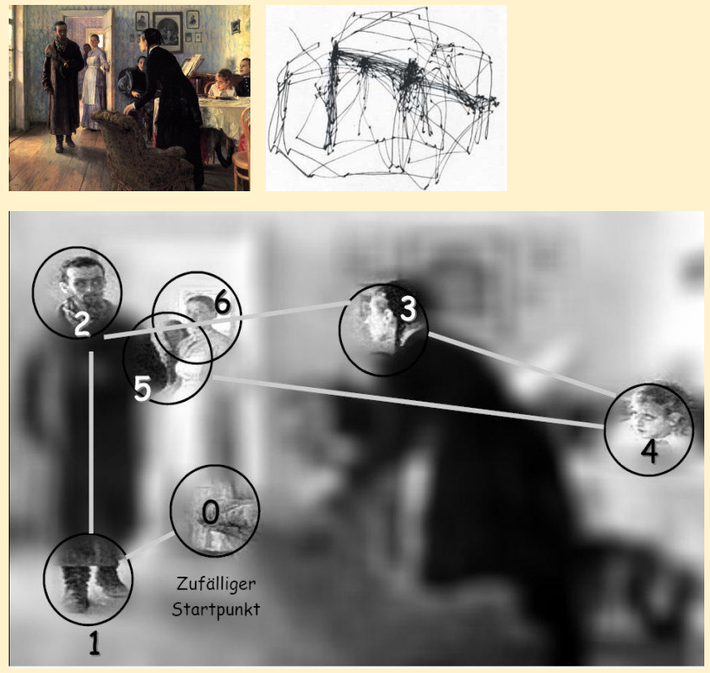
Human vision

COMPUTER VISION



(Girshick et al, 2015)

HUMAN VISION



(Yarbus, 1967)

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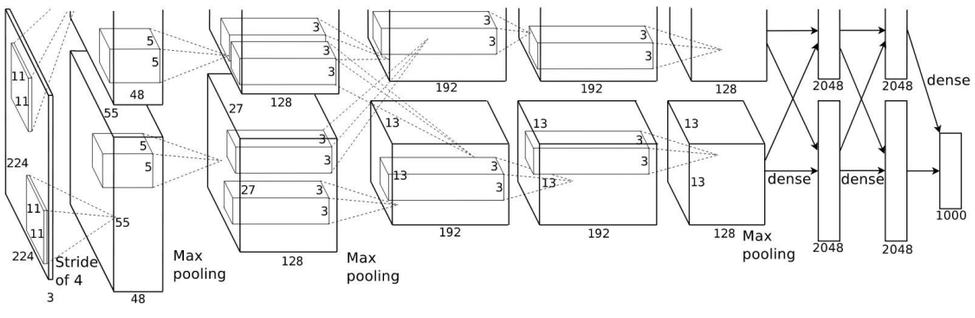

(Hinton et al, 2012)

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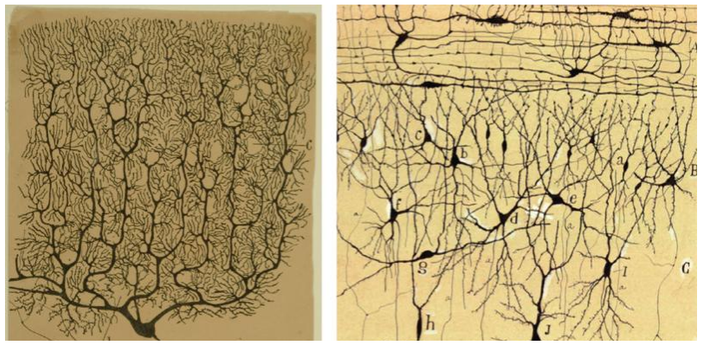


(Cajal, 1888)

Attention vs. Scene Understanding

Bayesian surprise (Information Gain) (Itti & Baldi, 2009)	E_y [log P(Y|*x*, *u*) − log P(Y)]

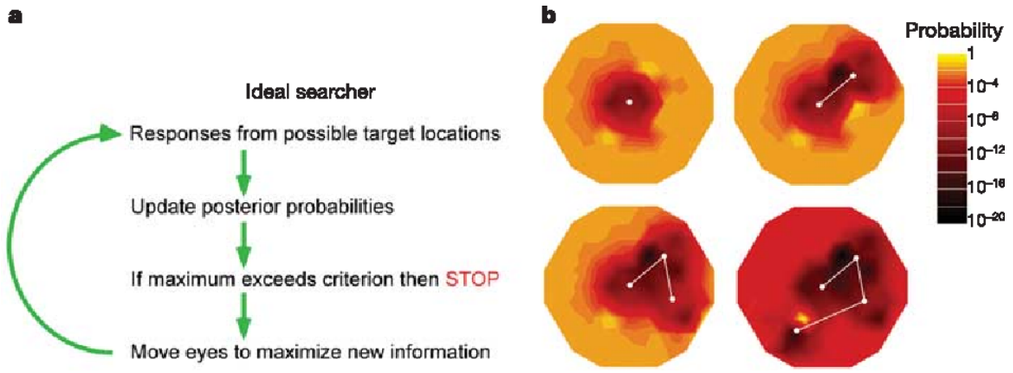
BOTTOM-UP

Visual attention
Saliency Maps

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

TOP-DOWN

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

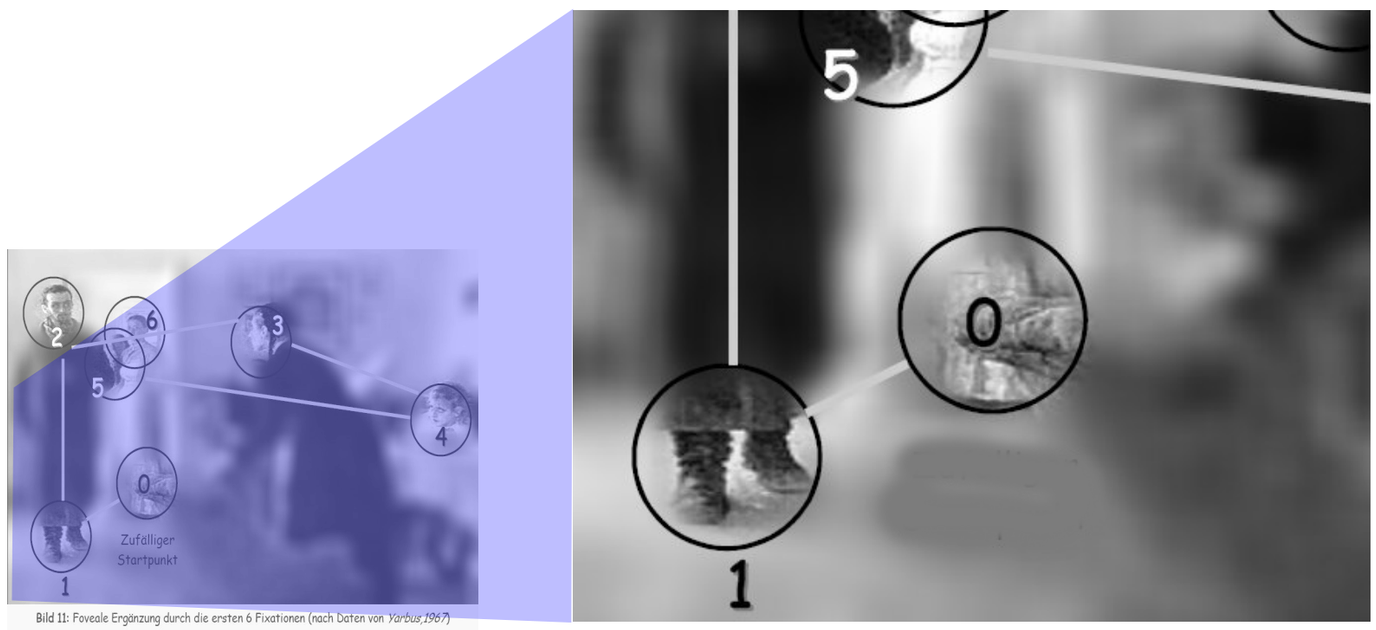


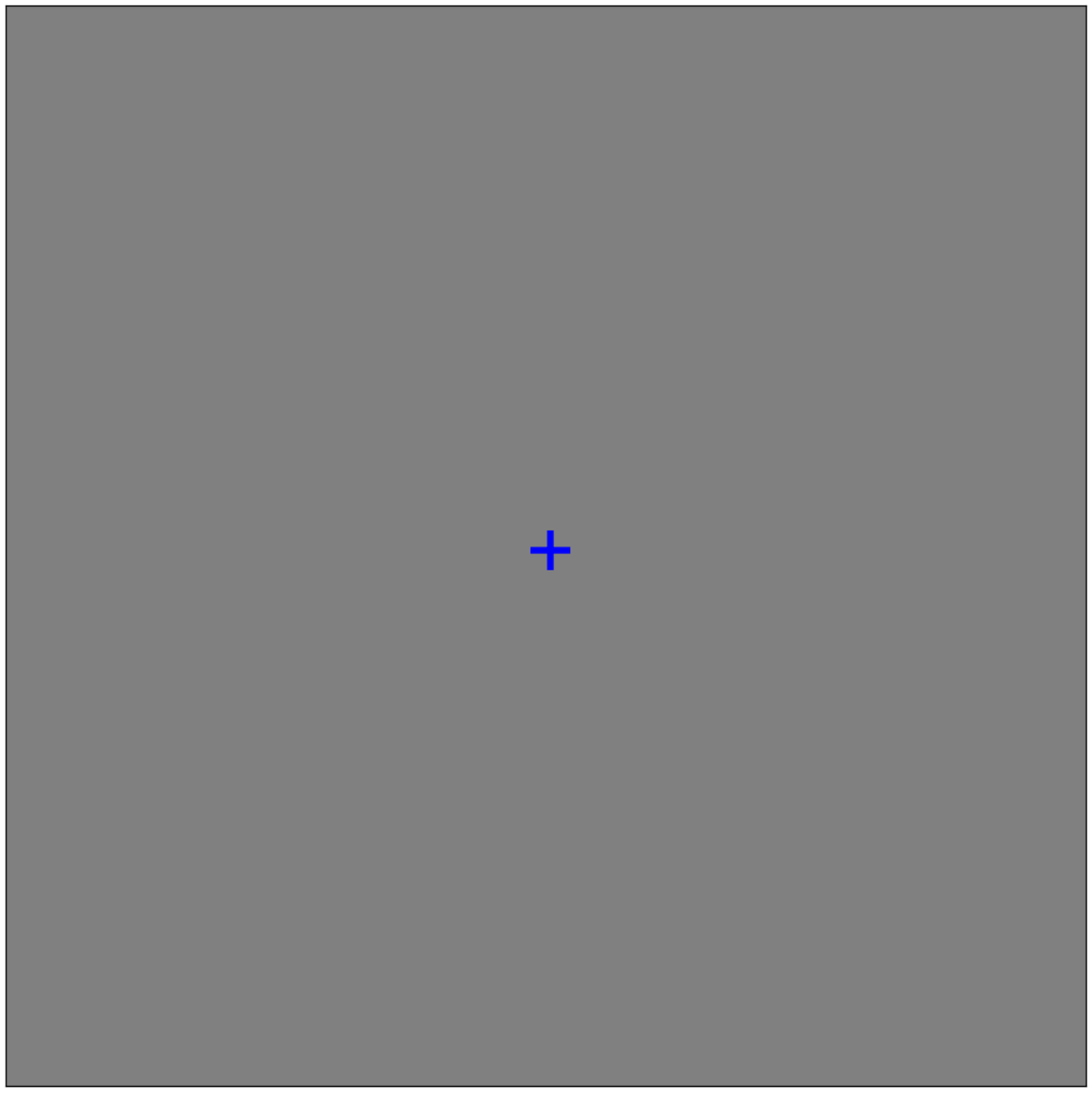
Bild 11: Foveale Ergänzung durch die ersten 6 Fixationen (nach Daten von *Yarbus,1967*)

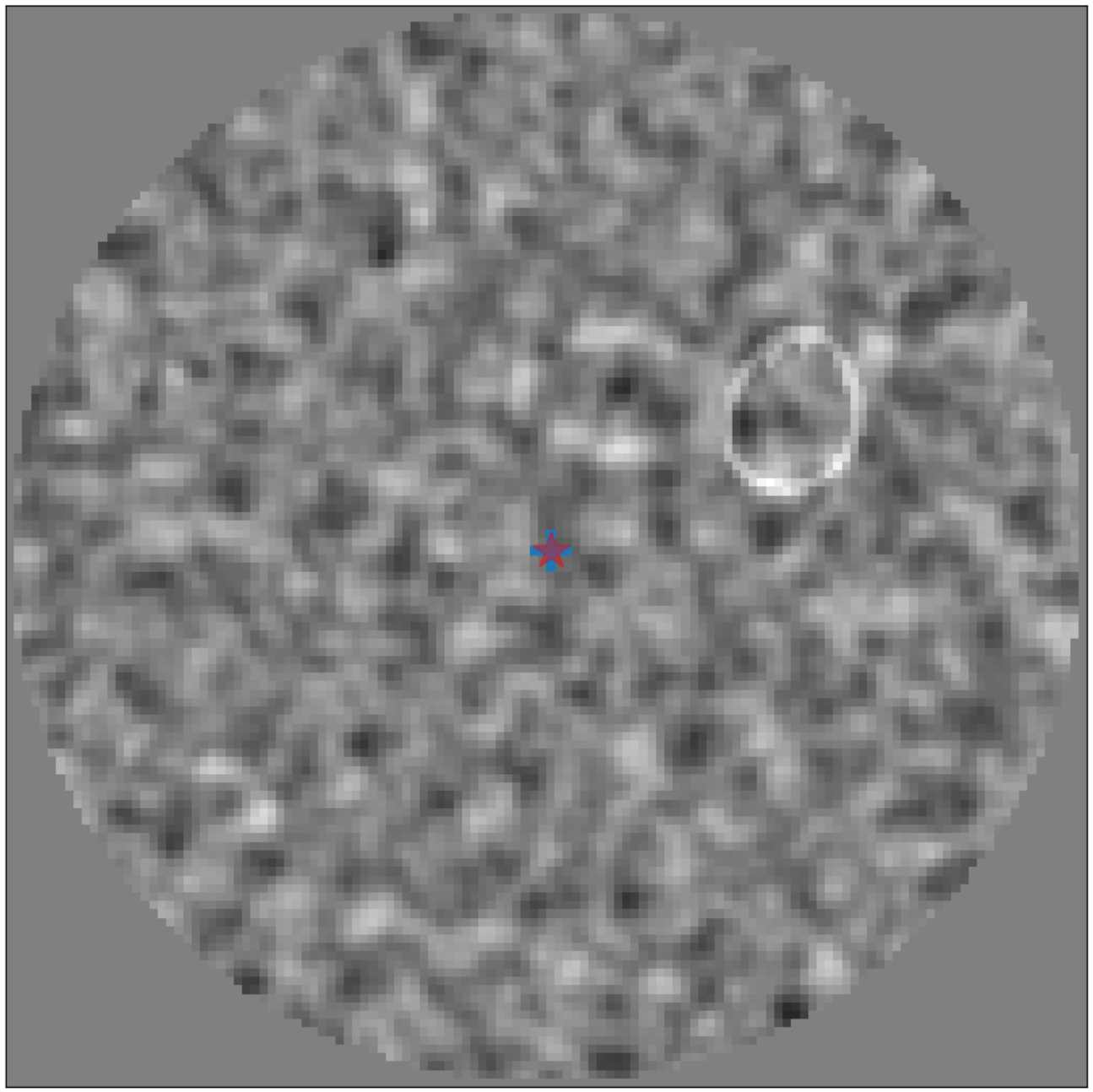
Information Gain :

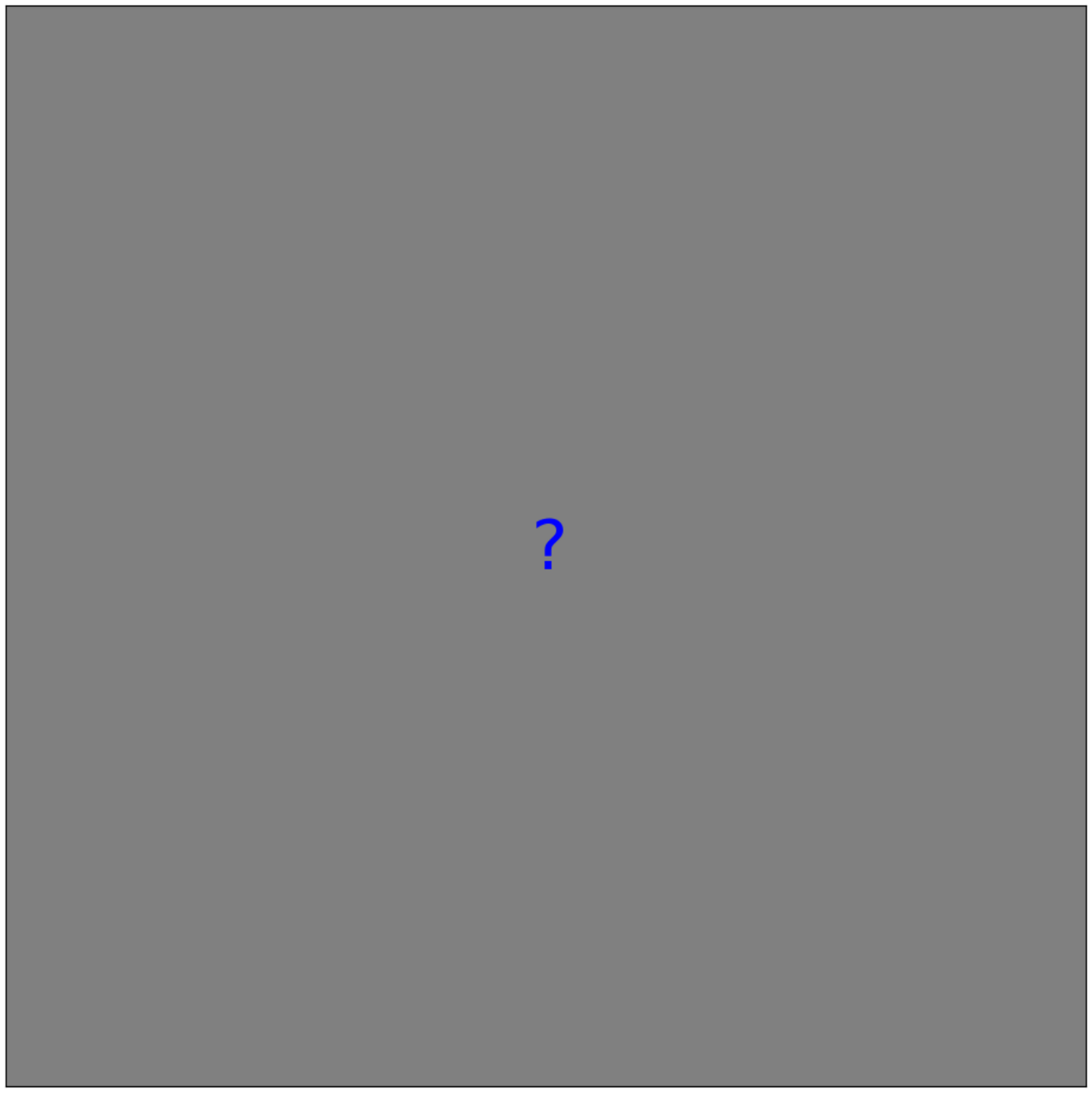
$$E_y [\log P(Y|x, u) - \log P(Y)]$$

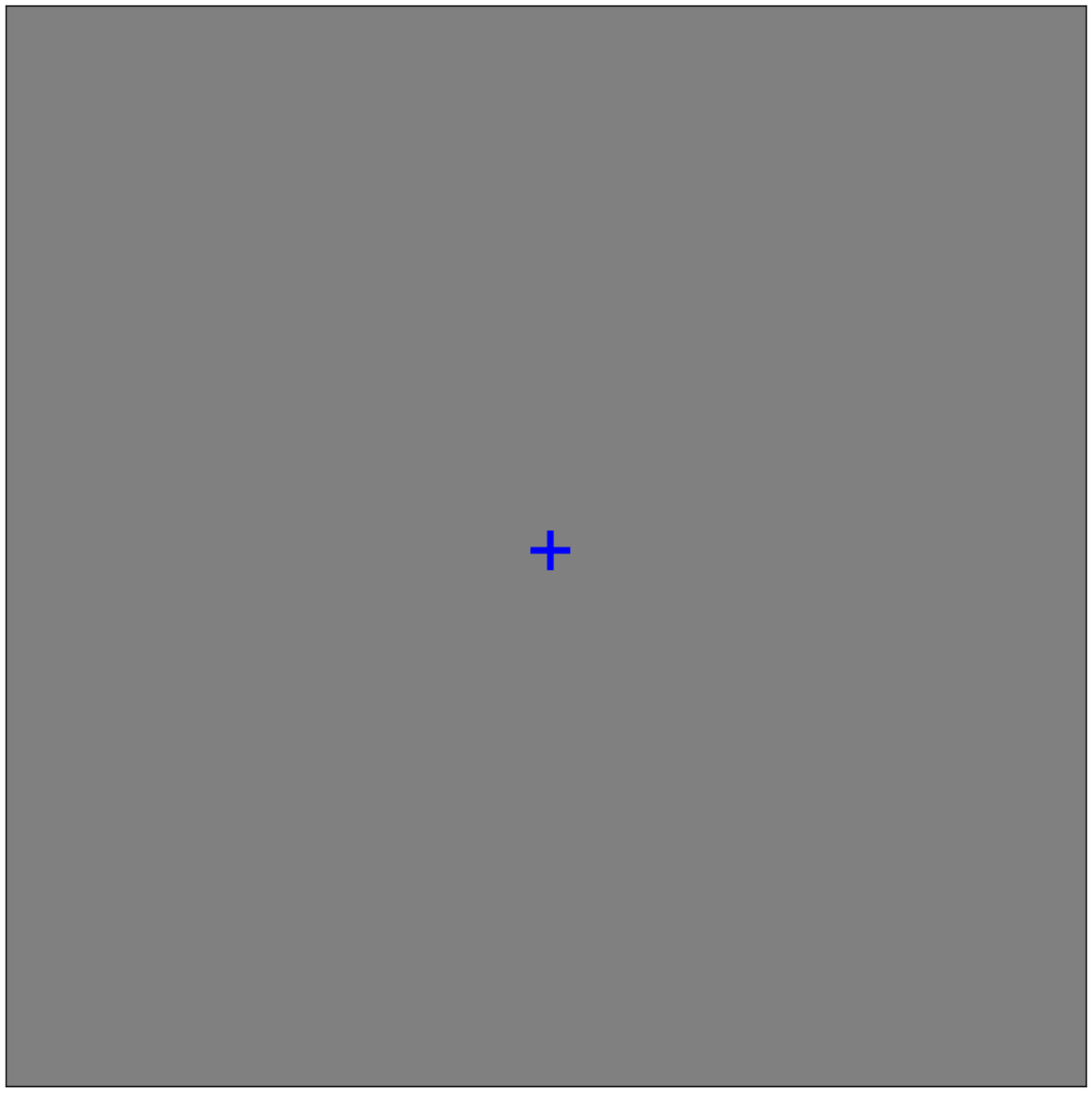
Peripheral processing

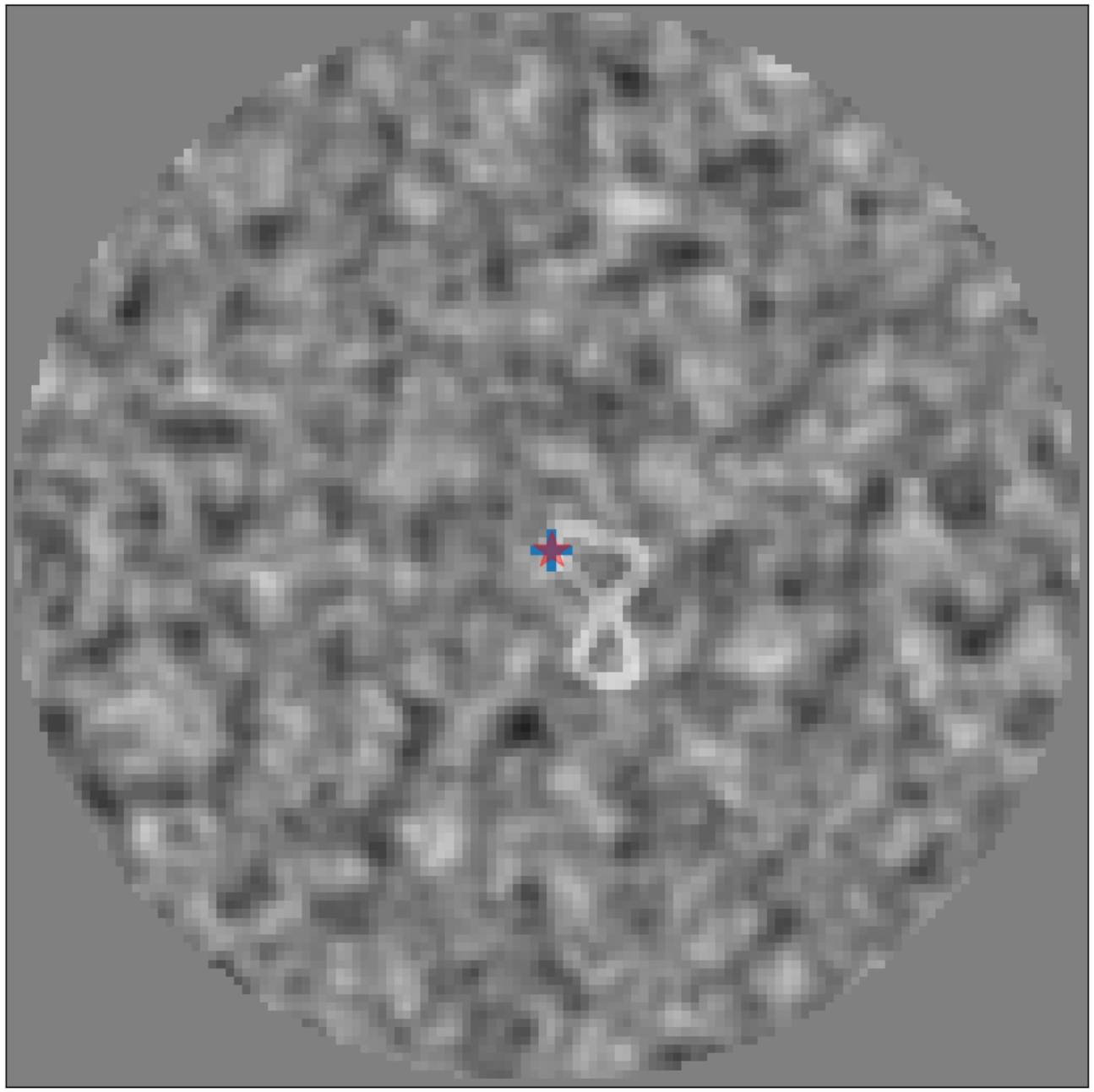
Central processing

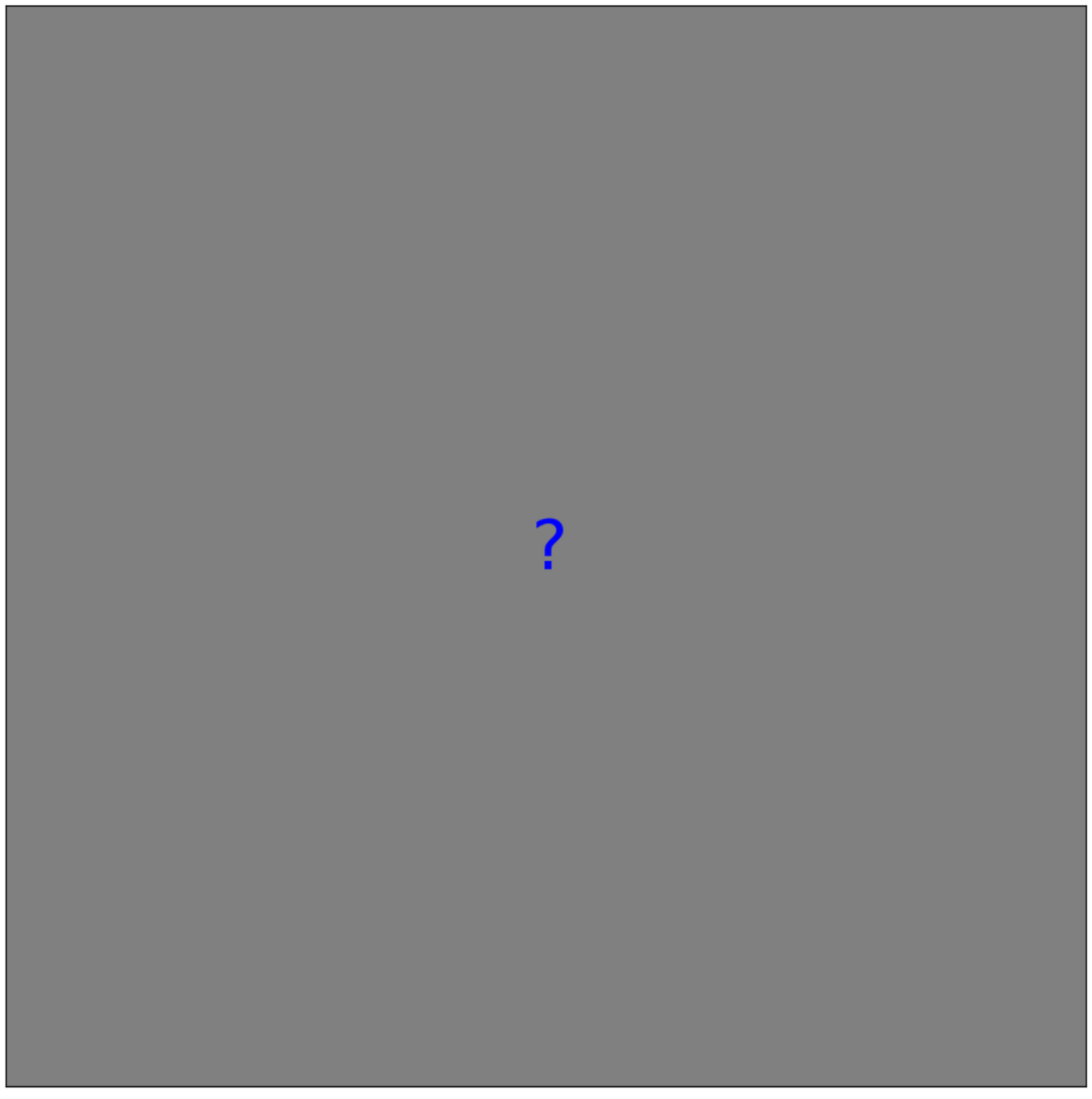


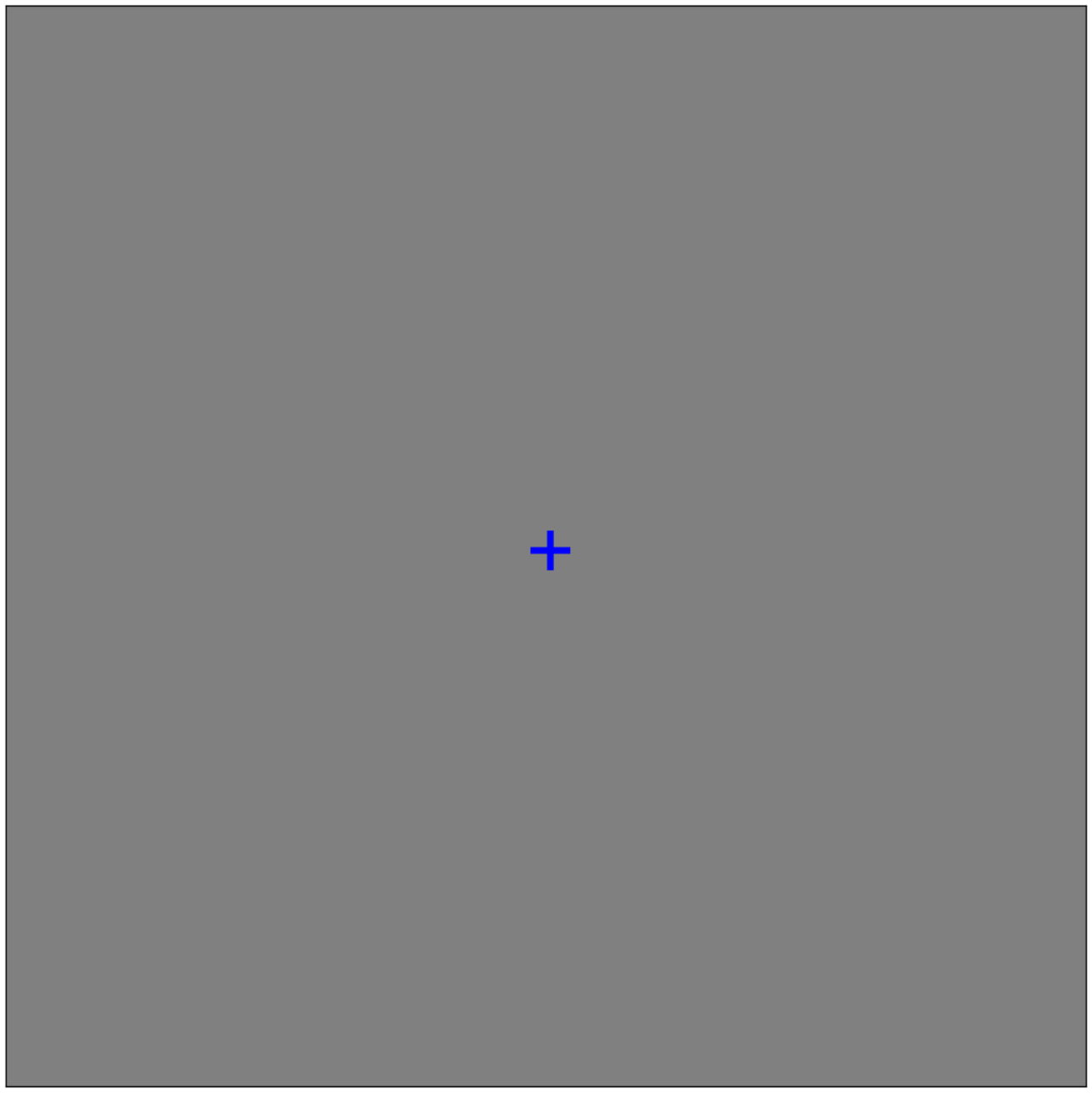


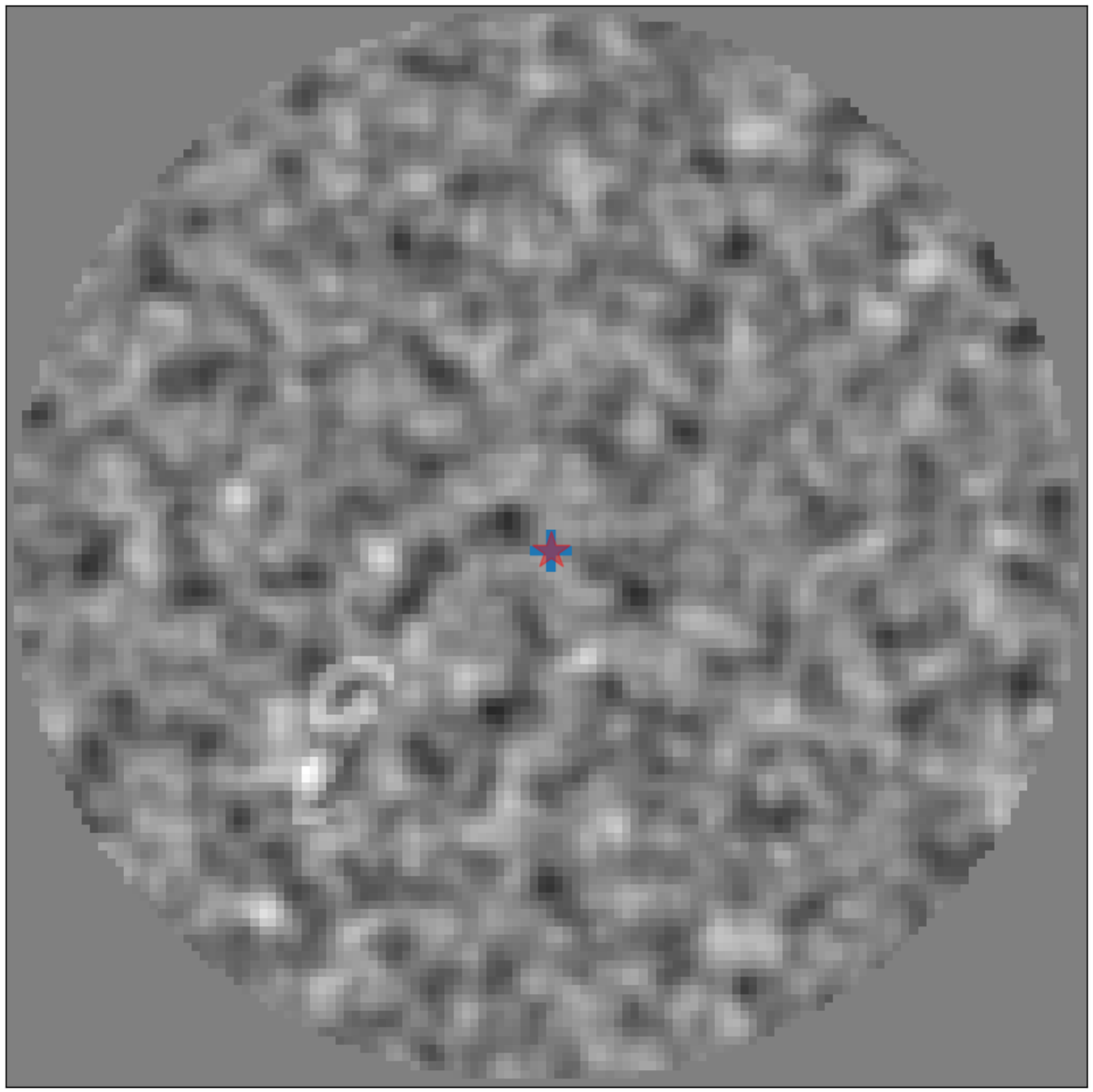


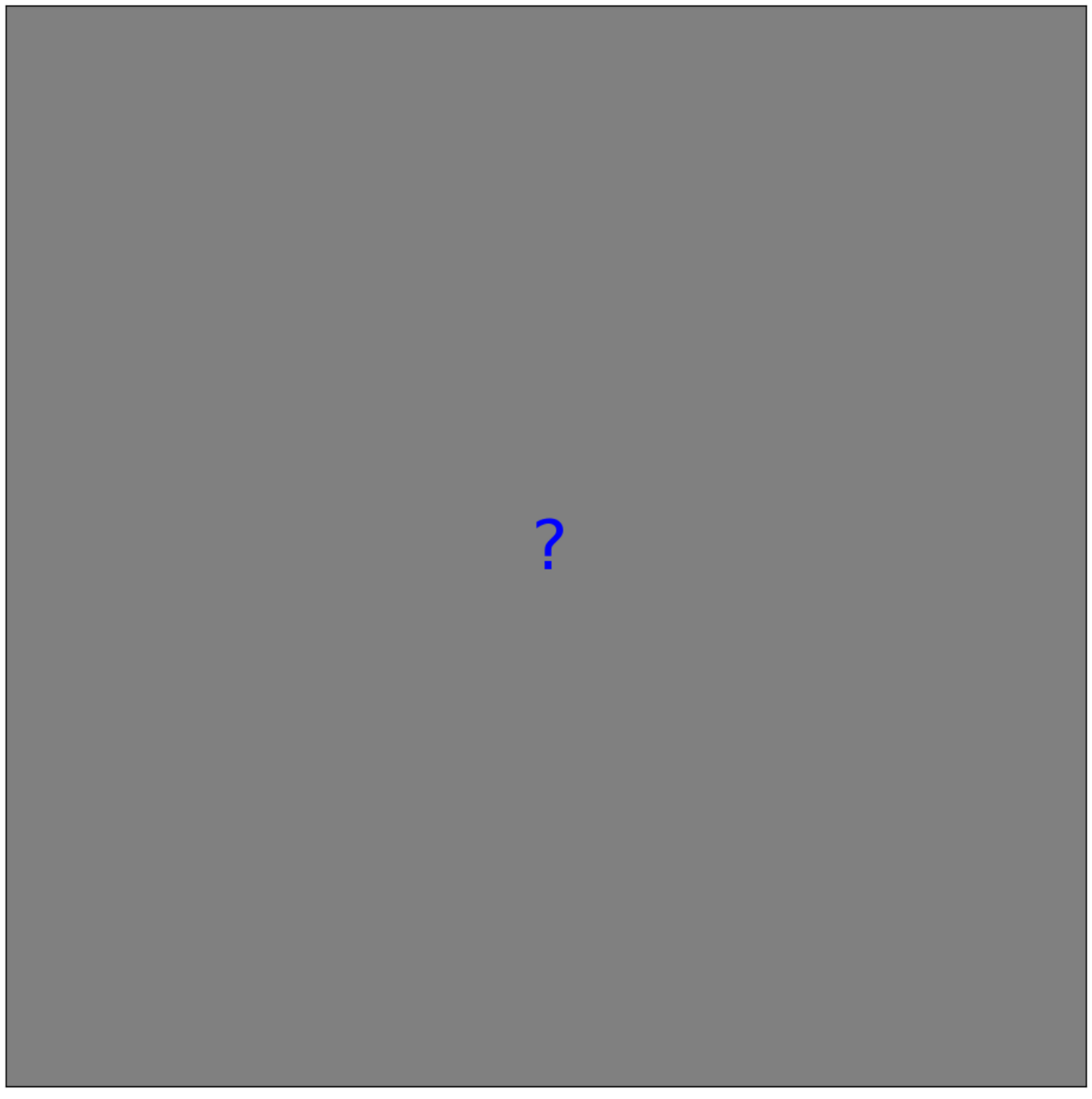


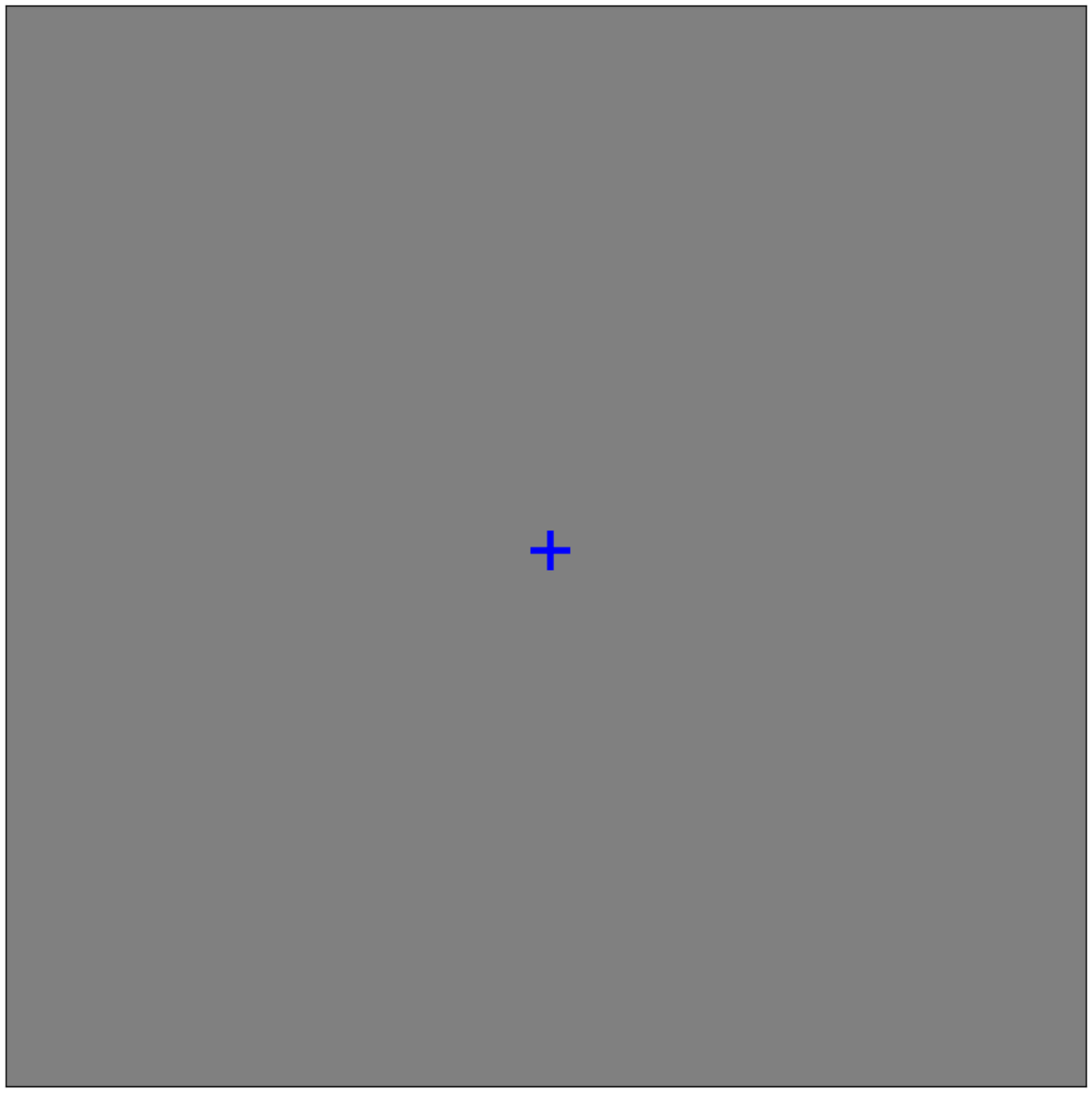


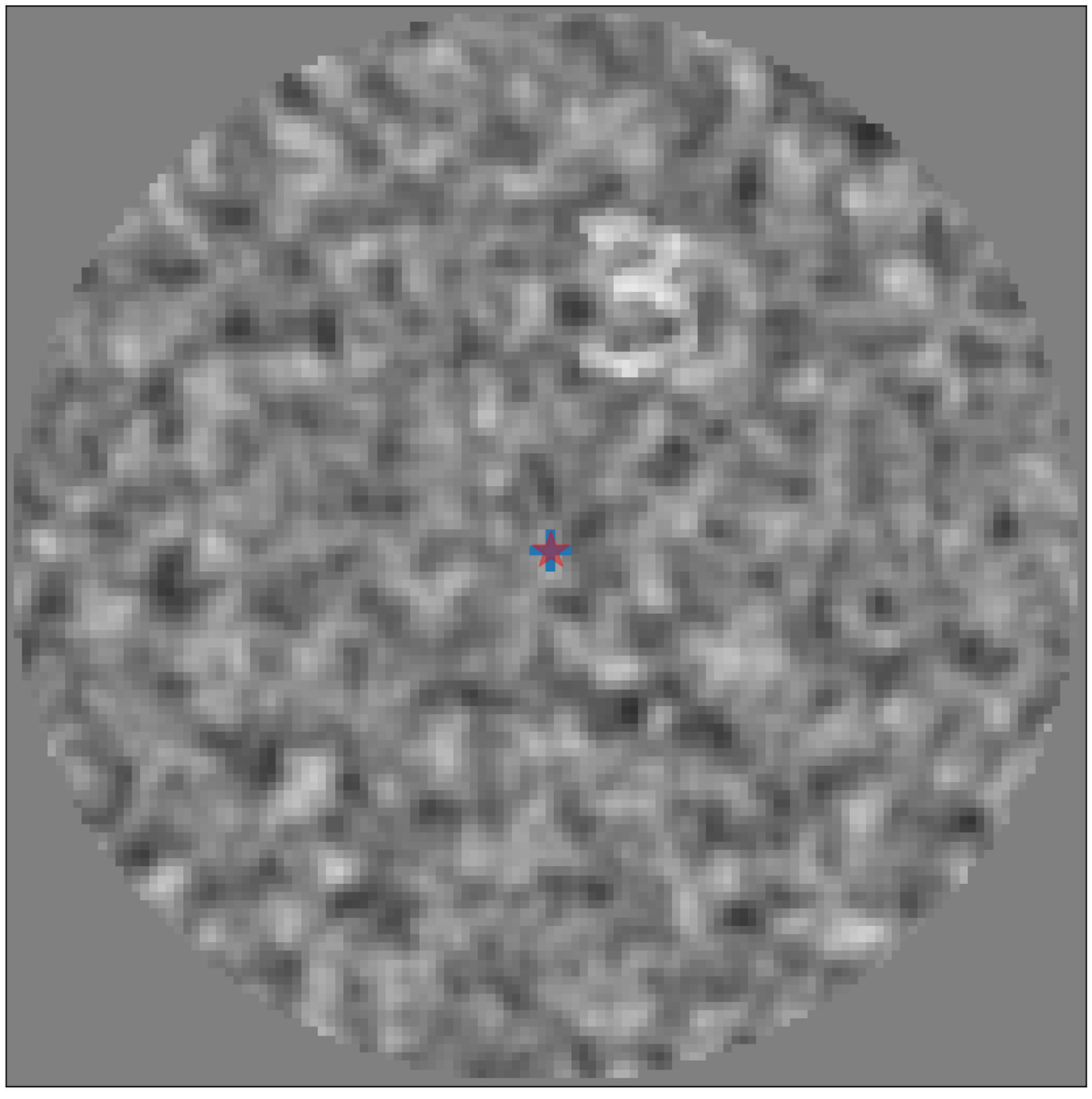


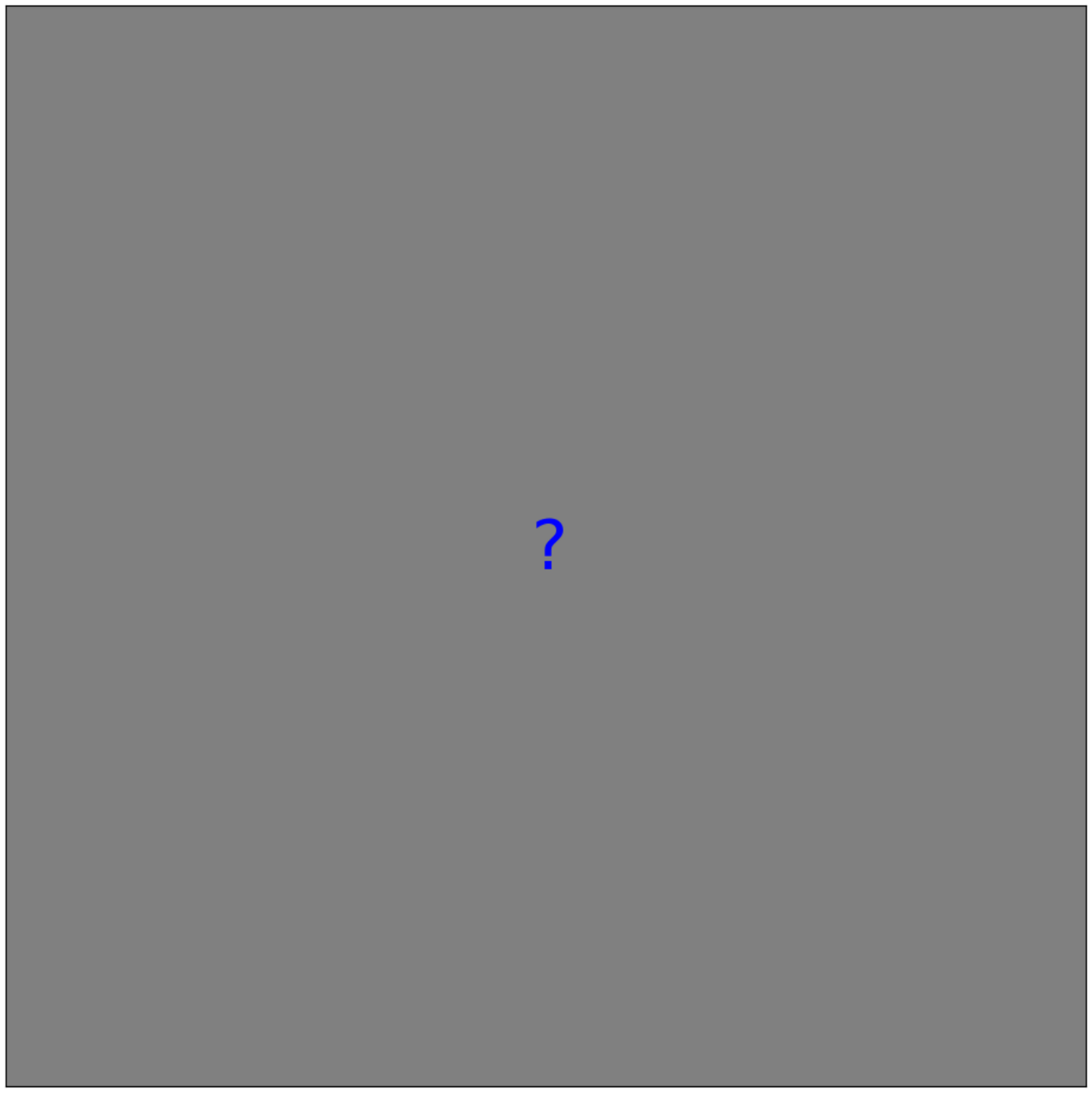




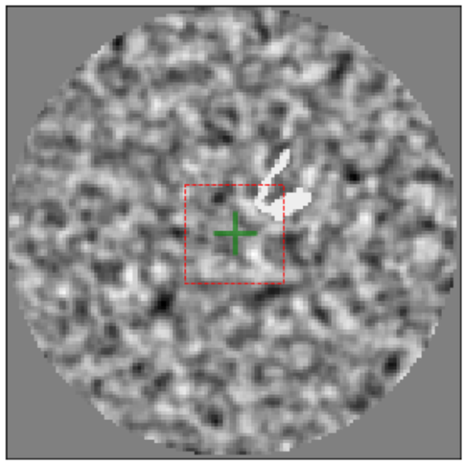


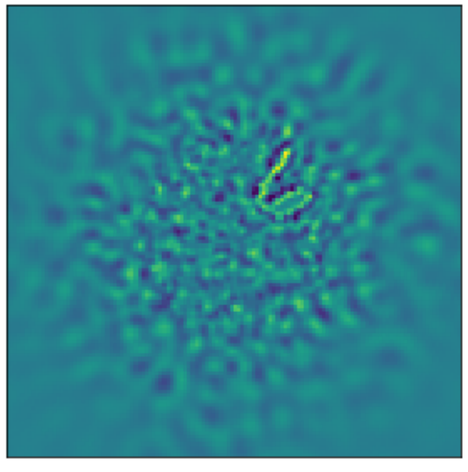


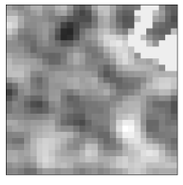




Methods: What/Where separation







Approximate Information Gain :

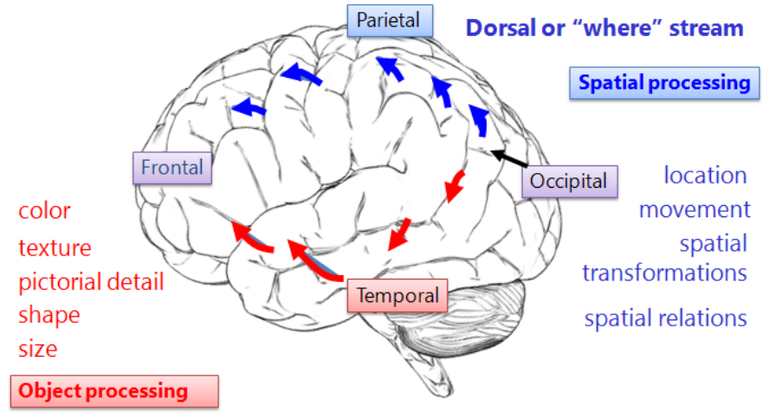
$$E_y[\log P(Y|x, u) - \log P(Y)]$$
$$\simeq$$
$$\log P(\hat{y}|x, u) - \log P(\hat{y})$$

Future Central Accuracy (after saccade)

Central Accuracy

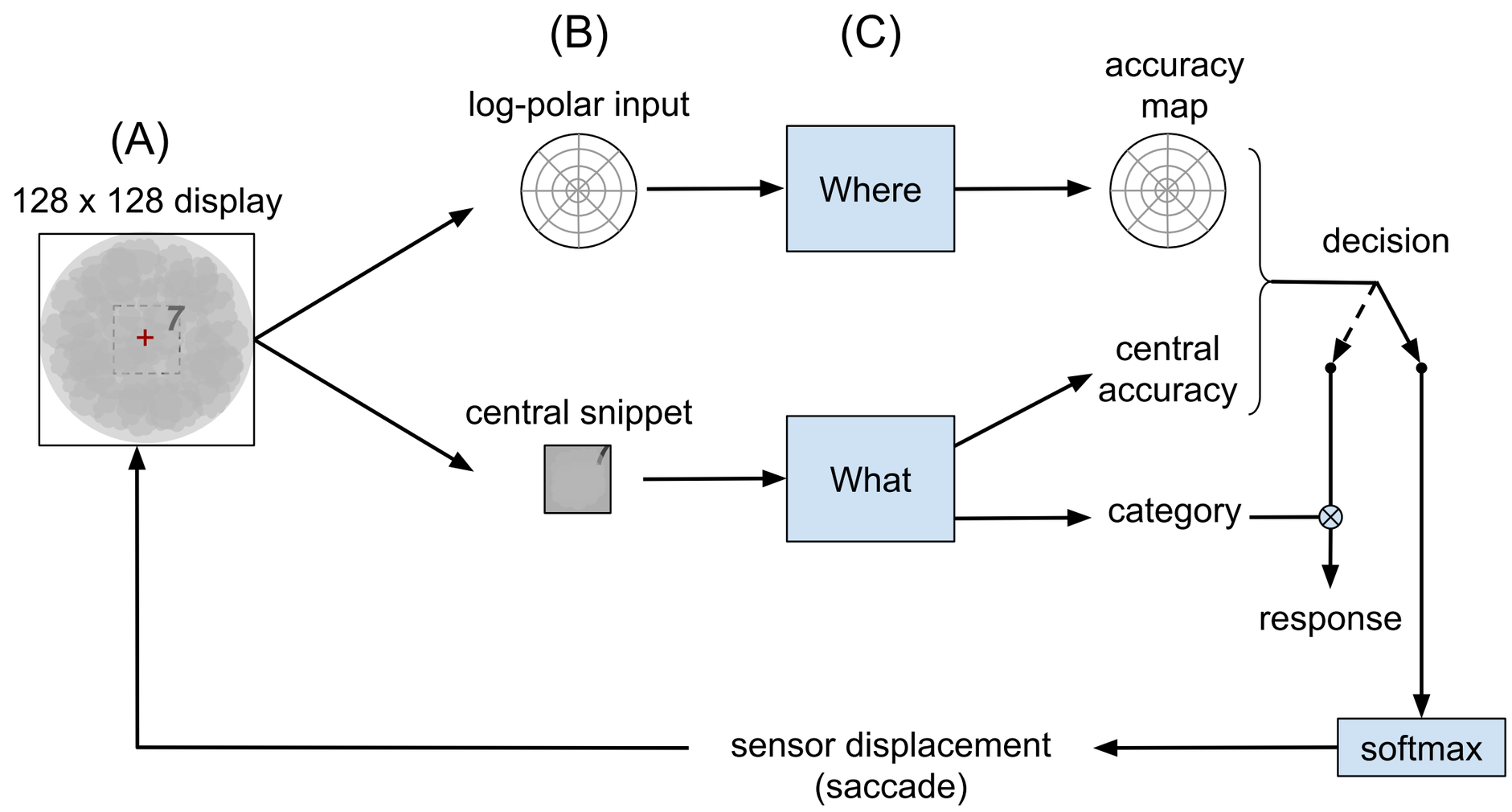
What/where pathways in visual processing

Mishkin, M., Ungerleider, L. G., & Macko, K. A. (1983).

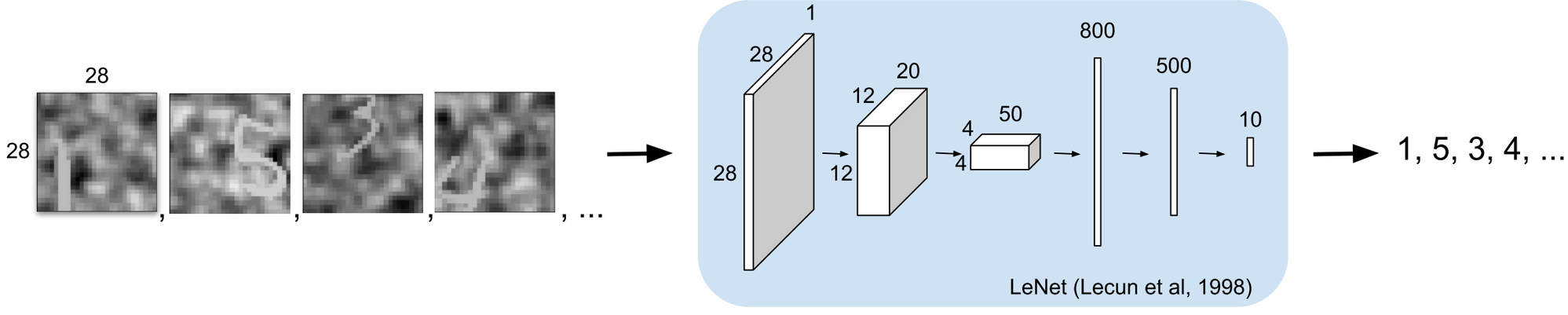


source: http://nmr.mgh.harvard.edu

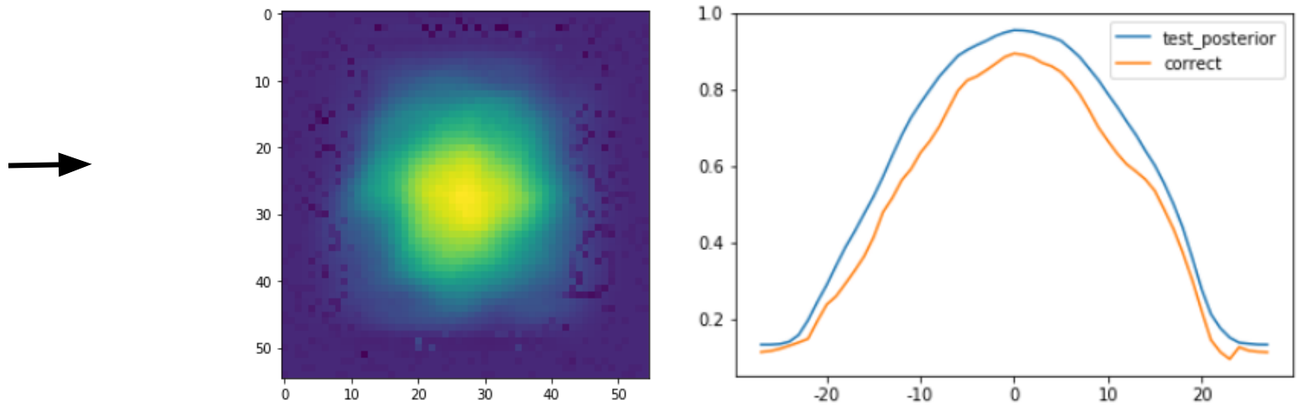
Methods: Computational Graph



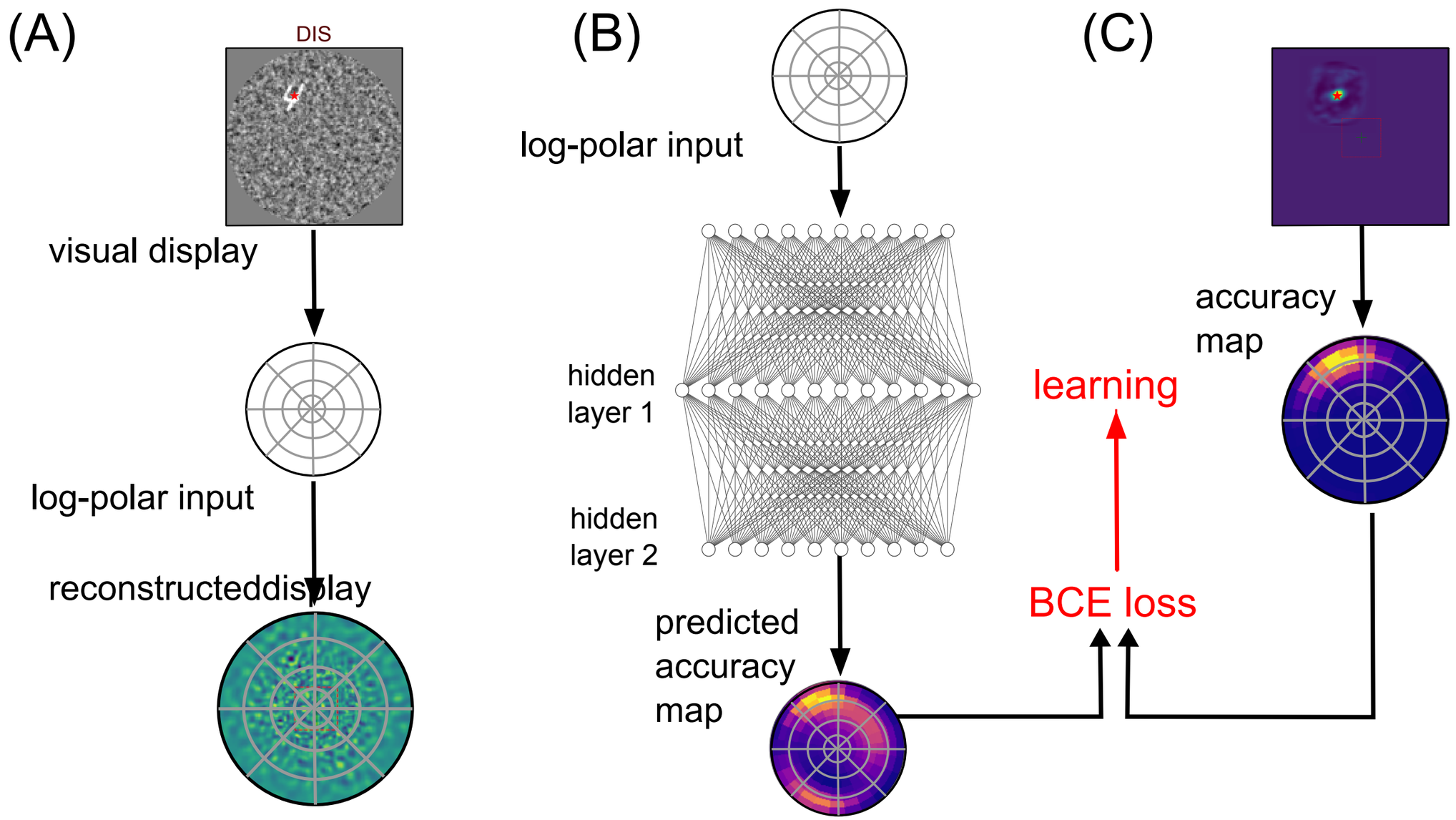
Methods: What



Shift-dependent Accuracy Map



Methods: Where



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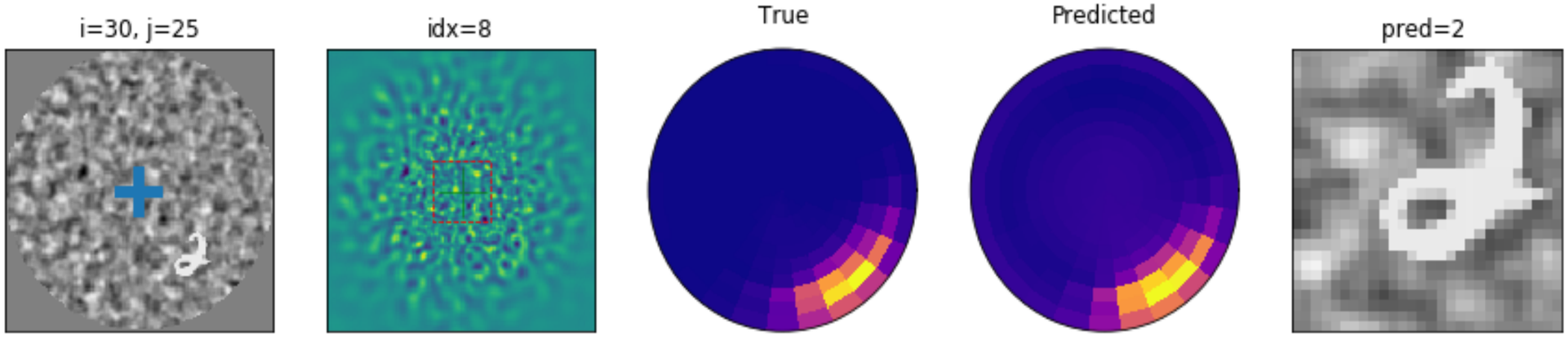
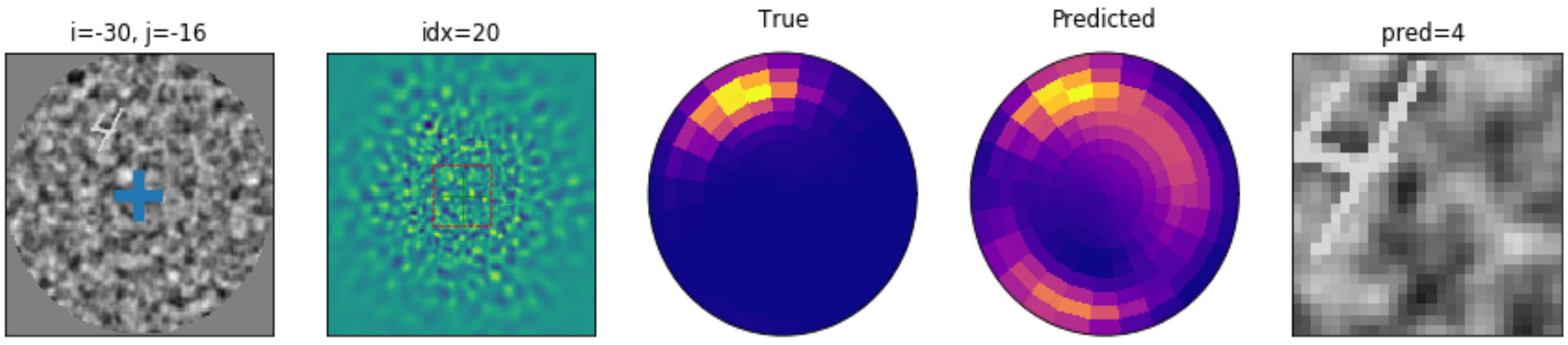
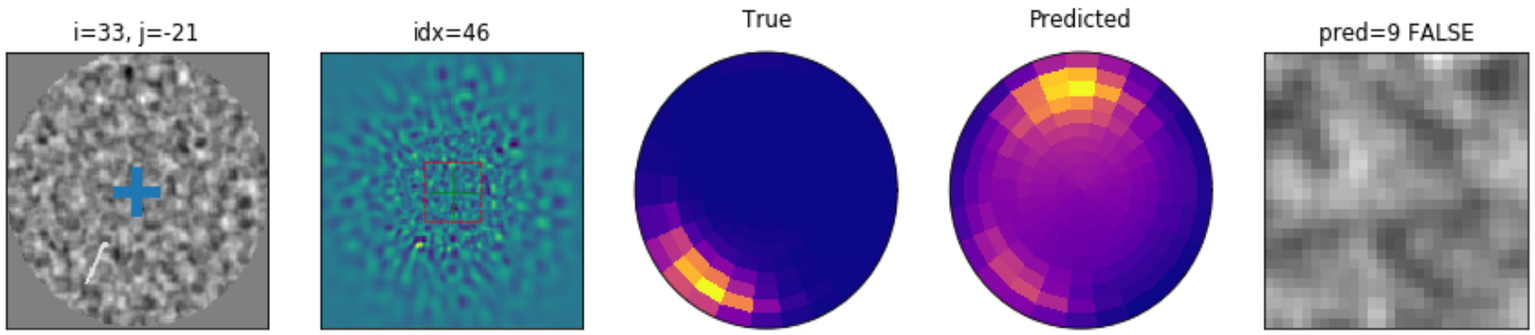
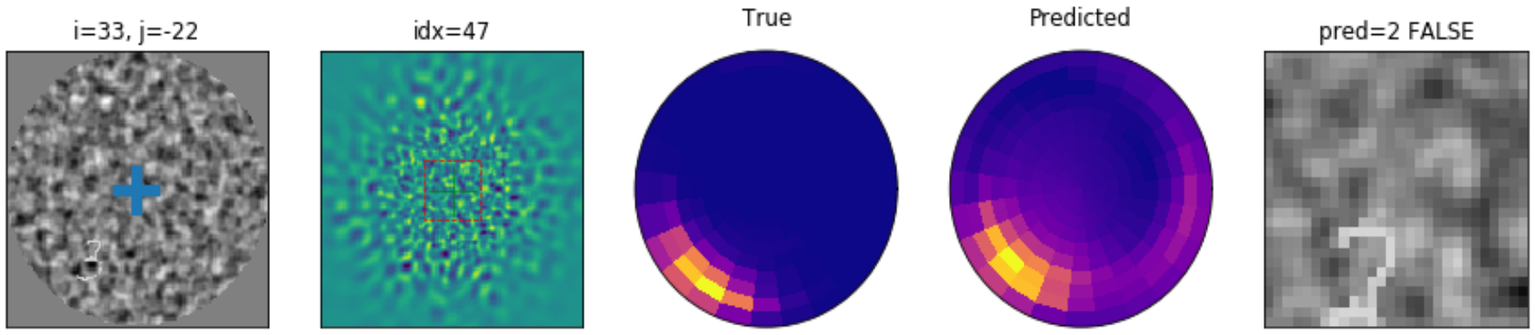
Results: success

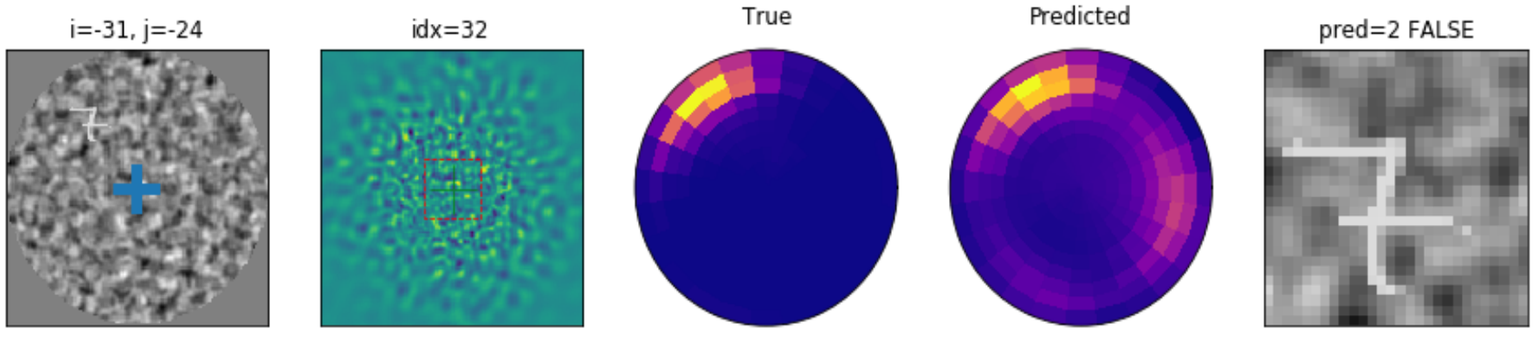




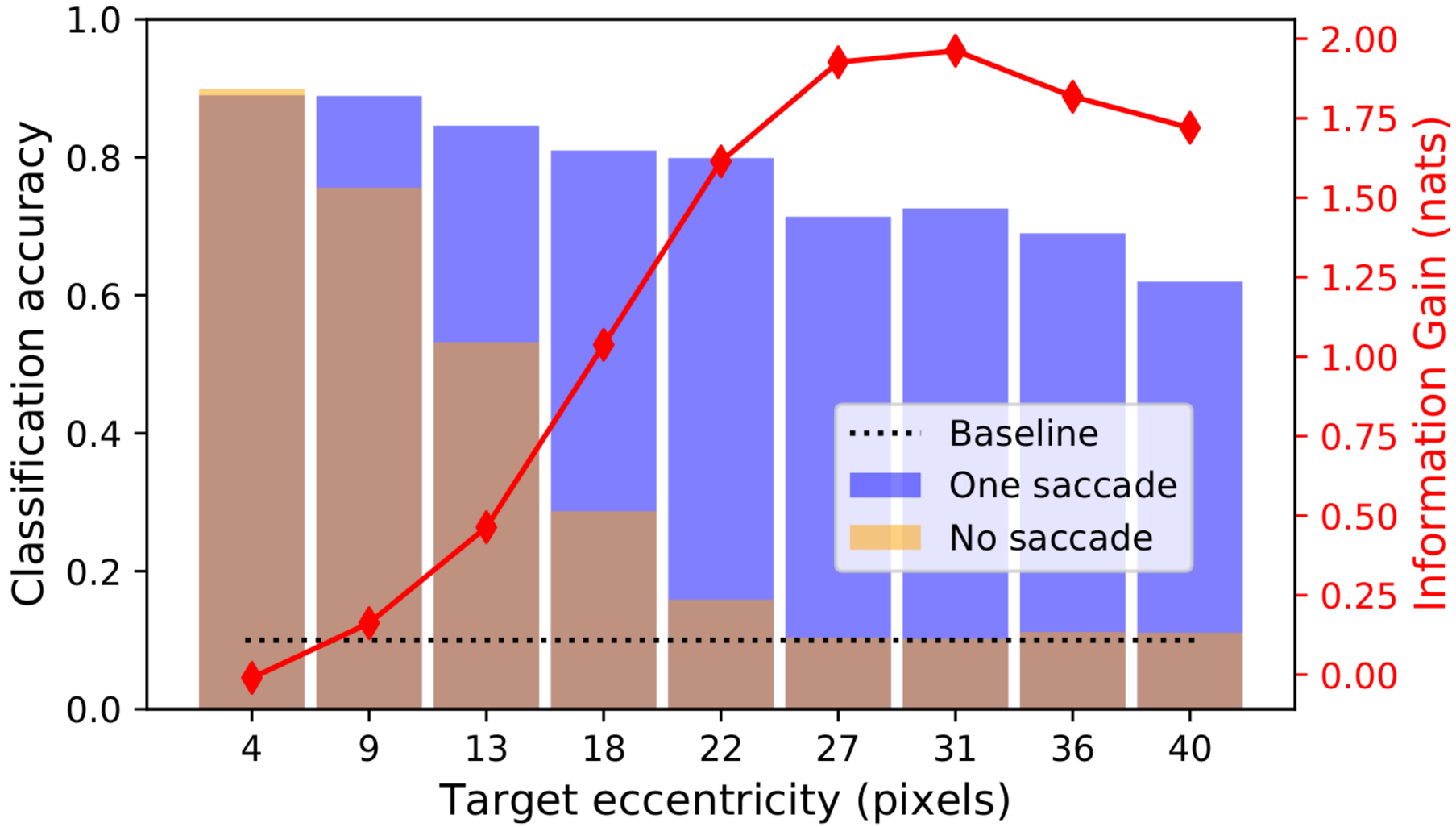
Results: failure



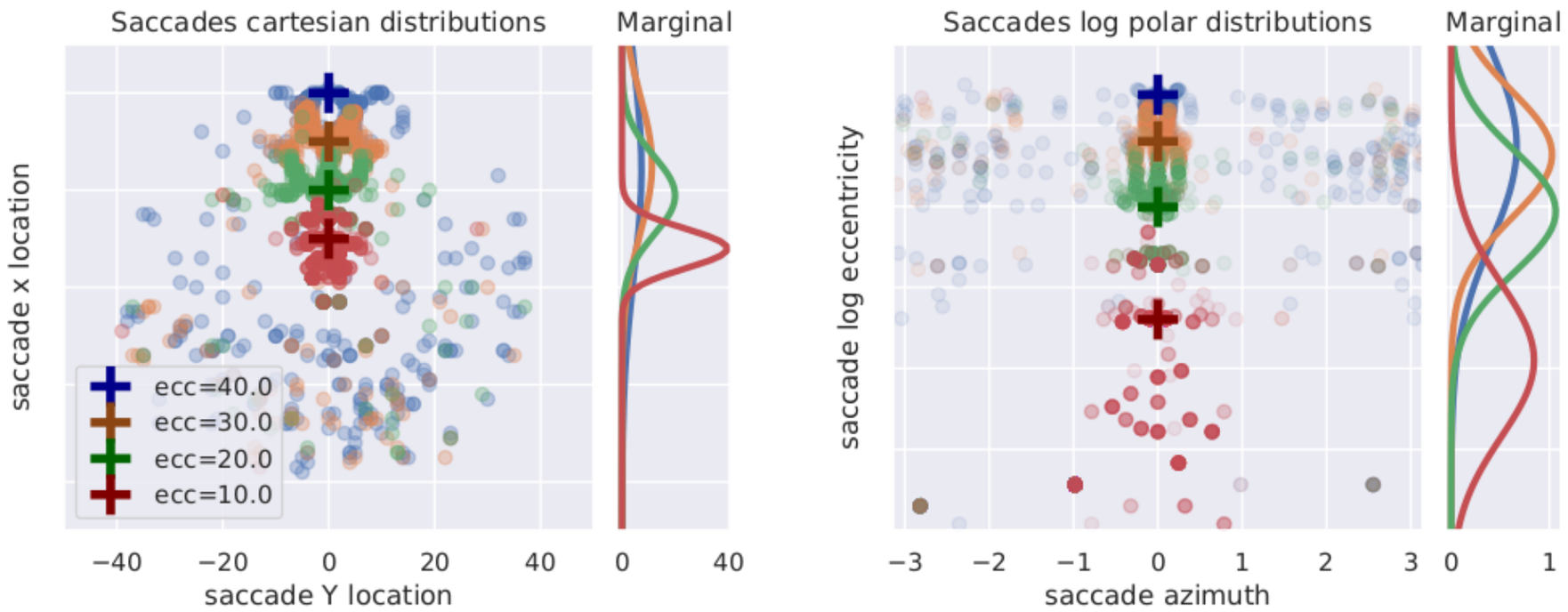




Effect of eccentricity



Saccades distribution



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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 (actor/critic)
- A sub-linear object detection for image processing:
  - A full log-polar processing pathway (from early vision toward action selection)
  - Ready for up-scaling
- The combination of accuracy predition and accuracy-seeking policies can be formally recast in an active inference framework (see paper)

Visual search as active inference

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https://laurentperrinet.github.io/talk/2020-09-14-iwai