

# The function of cue-driven feature-based feedback in object recognition

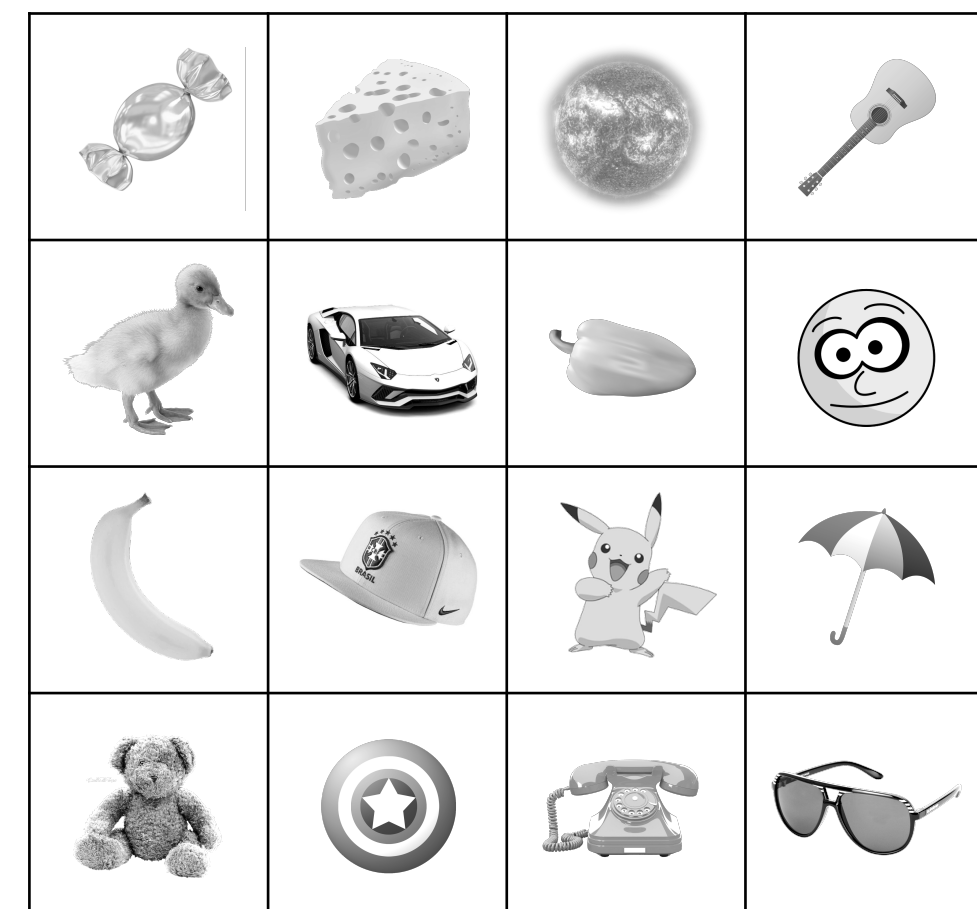
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## Cues help in recognising objects

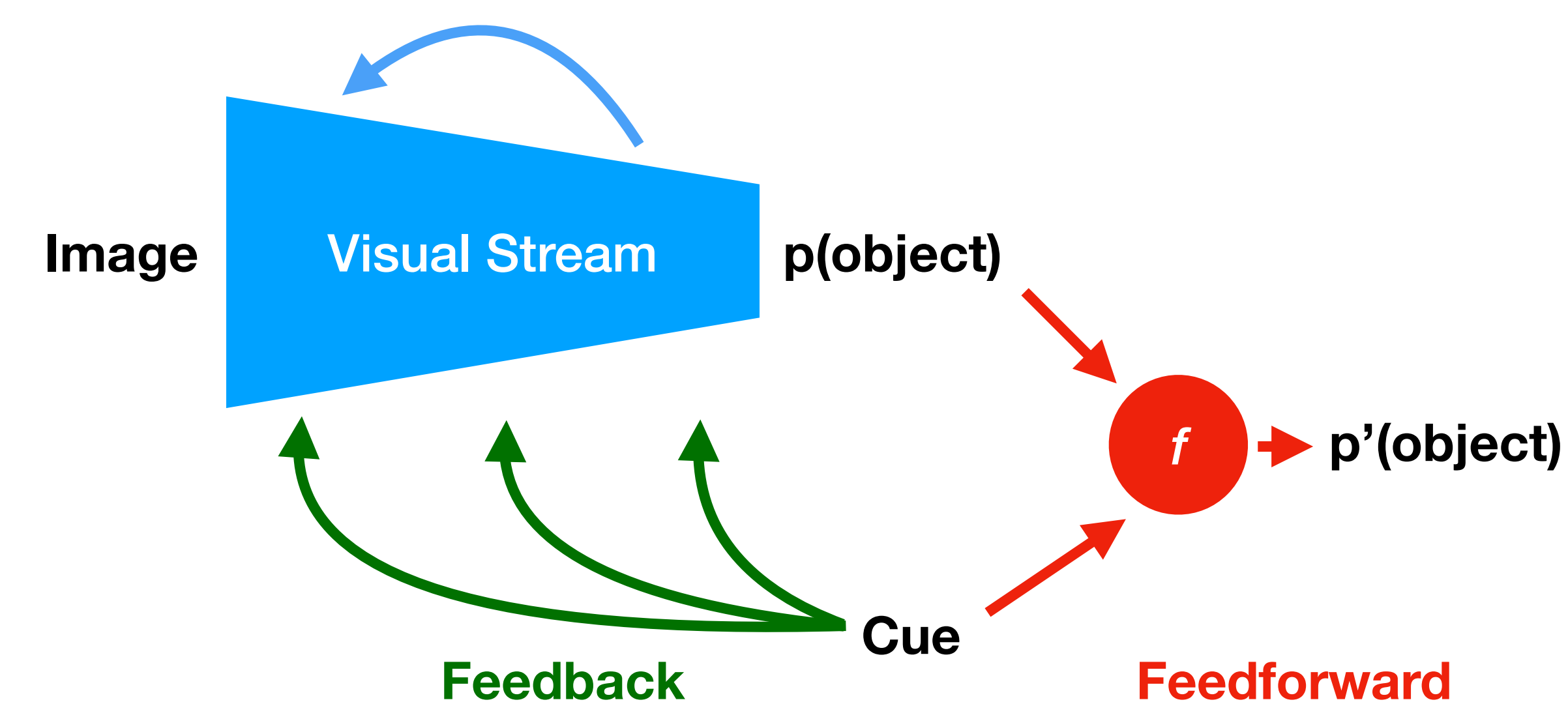
(via Expectation<sup>1</sup> & Attention<sup>2</sup>)

Is there an animal in the image?



How, and when, does cue information aid object recognition, via feedforward and/or feedback interactions?

## Interactions b/w cue & visual stream



## When is feedback useful?

When the visual stream cannot completely represent task-relevant features. Why? **Capacity limits.**

### 1. Neural capacity (NC)

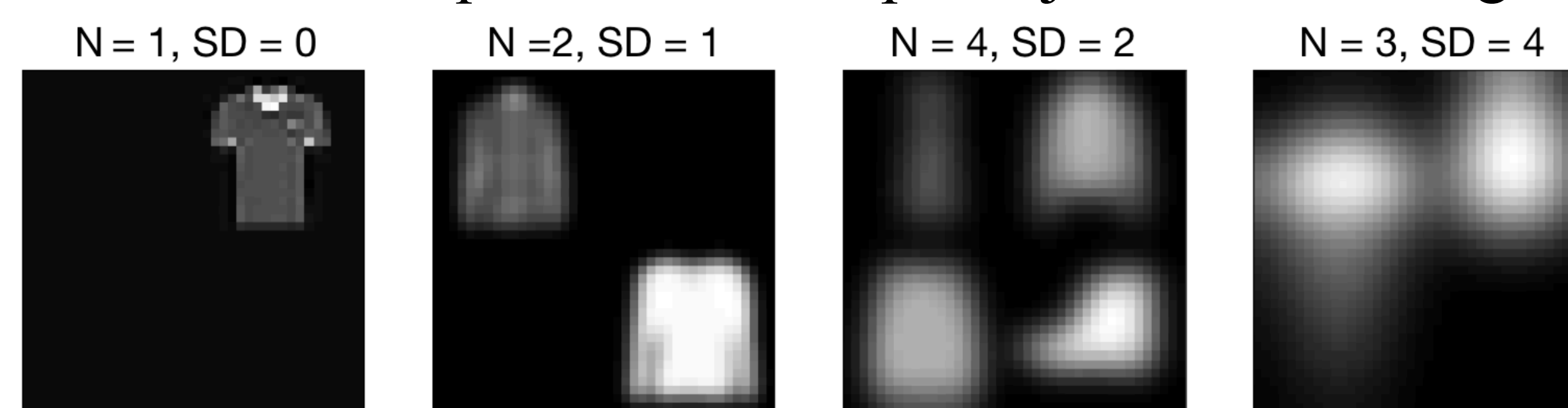
- # of learnable parameters (connectivity & neural dynamics)

### 2. Representational capacity (RC)

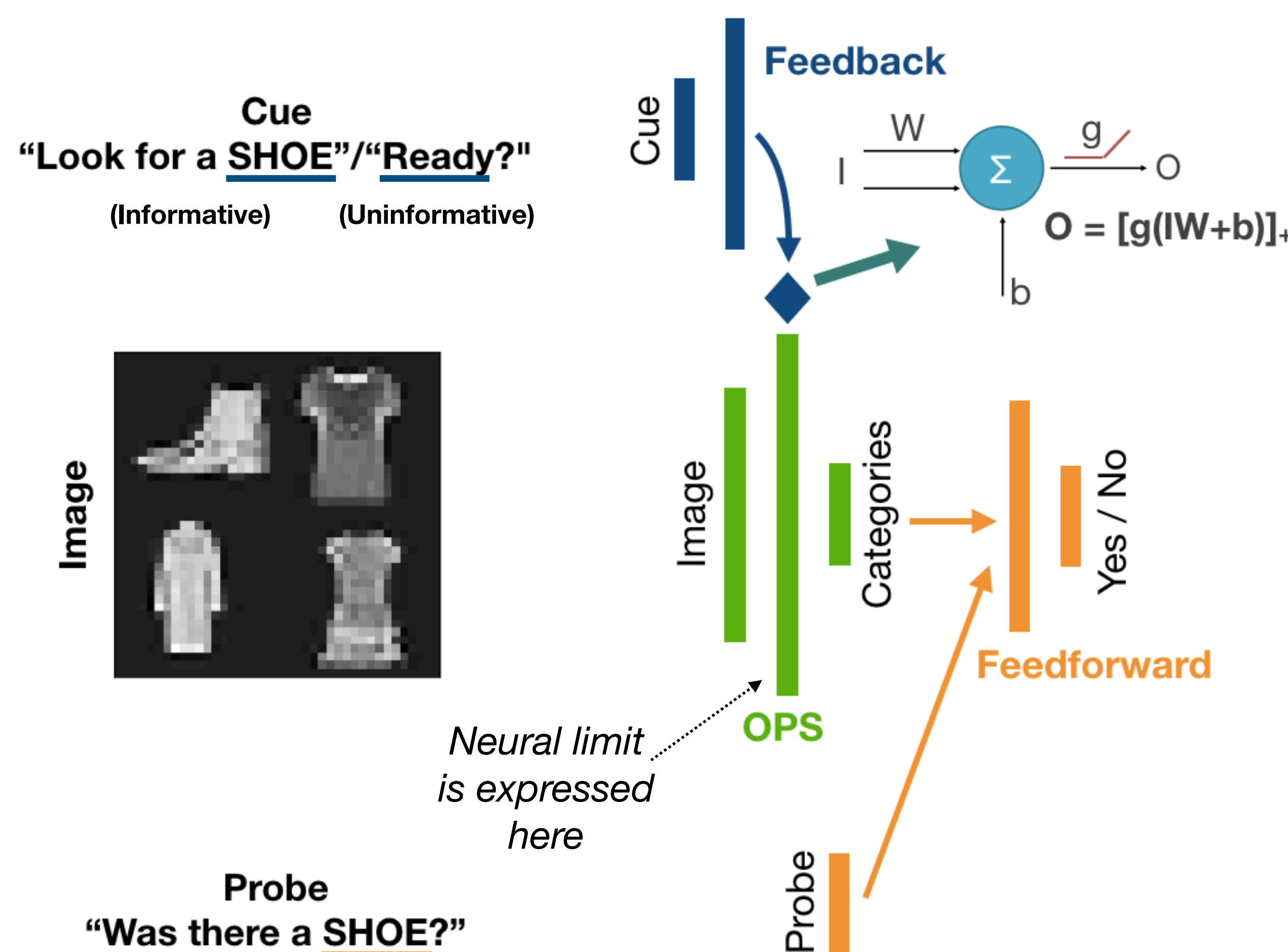
- Extent of the input space mapped to the outputs in the model through training. Rest is *out-of-sample*.

Feedback might help with early feature selection.

Feature manipulations: Multiple objects and blurring



## Feedback in a simple neural network



3 neural capacities:

- 8/32/3072 object-processing stream (OPS) nodes

2 representational capacities:

- Low RC - Train on intact, single objects
- High RC - Train of all feature manipulations

## Training the network

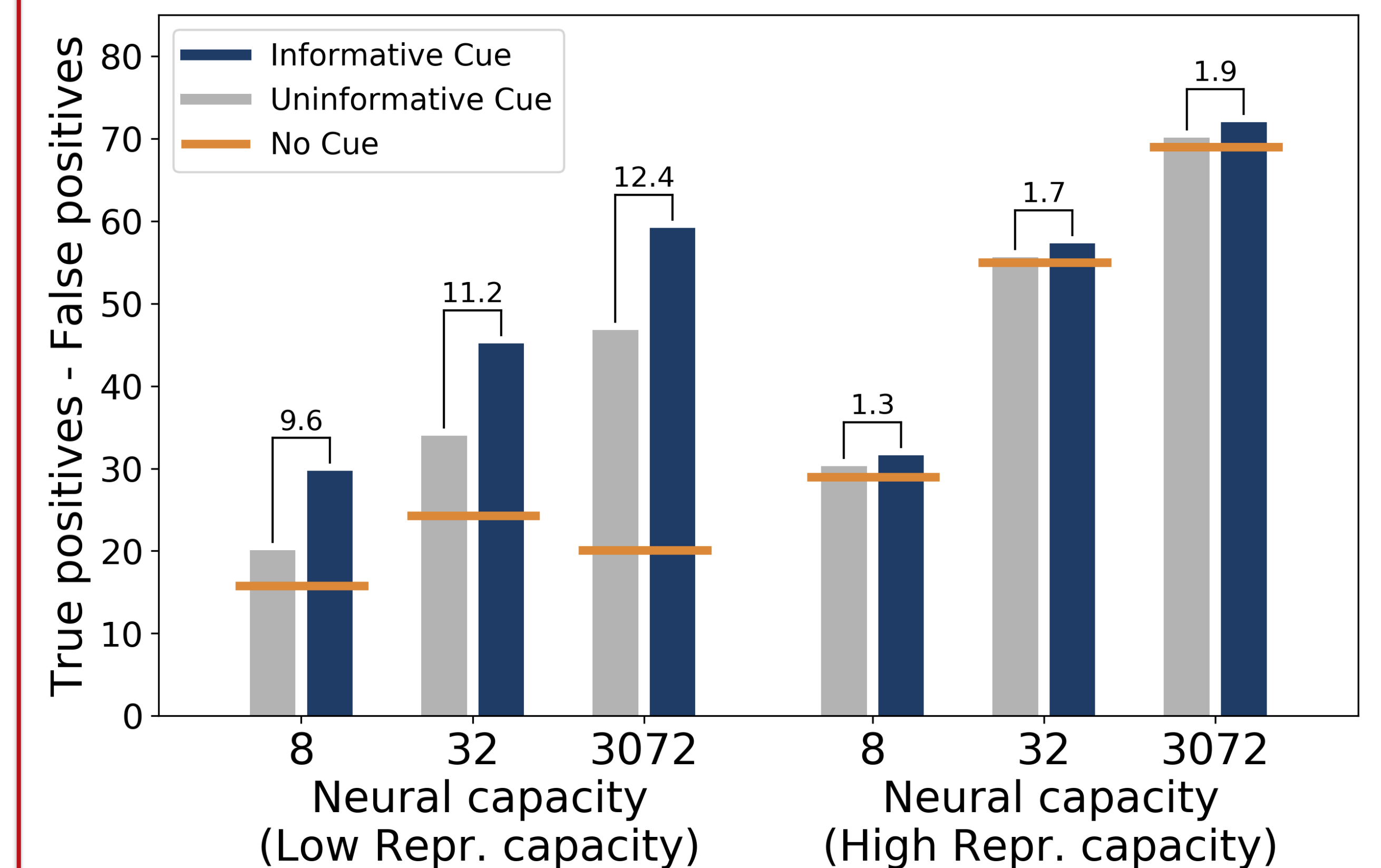
**3-step training:** (on fashion-MNIST<sup>3</sup> images)  
(with SGD + Dropout, after each step that NN is frozen)

1. Train OPS, given NC & RC, image → label(s)
2. Train probe NN, image + probe → decision
3. Train cue NN, image + probe + cue → decision

- **Maximise TP - FP** in (2) & (3)

Uninformative cue is mapped to all categories (*baseline*)

## Observations



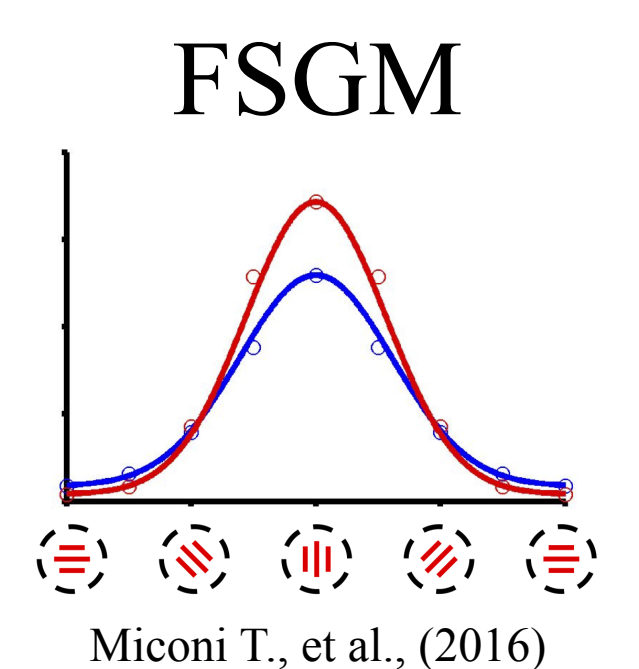
**The benefit of using the informative cue (via feedback) is manifested only when a representational capacity limit exists.**

- Similar trends were observed with a CNN as the OPS.

## Nature of feedback

1. Tuning-based feedback performance (feature similarity gain model<sup>4,5</sup>) → TP - FP ≤ 3%
2. FSGM templates **do not** correlate with trained feedback templates

**3. Any alternate formulations?**



## Conclusion

Cues aid object recognition *via feedback* only when there is a *representational* capacity limit on object processing.

## References

1. Bar M. Nat. Rev. Neuro. 2004
2. Carrasco M. Vision Research. 2011
3. Xiao H, et al. arXiv. 2017
4. Martinez-Trujillo JC, Treue S. Curr. Bio.2004
5. Lindsay GW, Miller KD. bioRxiv. 2018

