Image- and Task-Based Contributions to Object Detection in Natural Scenes

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Background

To assess object detection in natural scenes[1] we introduced a task in which observers indicated whether a briefly exposed dot was "on" or "off" the object bounded by the nearest contour[2,3]
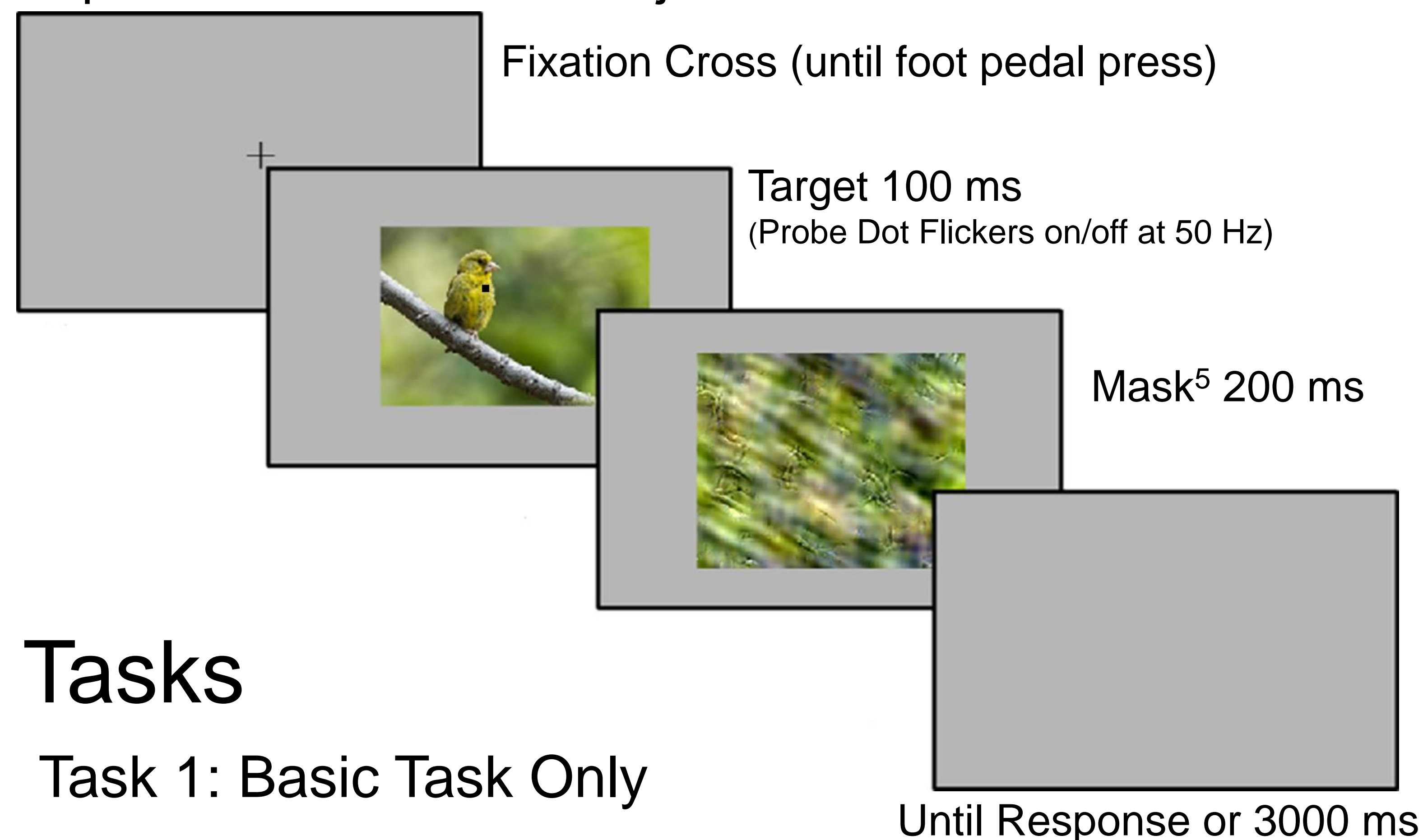
- Unlike 2AFC categorization tasks, responses can't be guessed based on scene context[4]

We test how detection sensitivity and criterion vary with:
1) task conditions encouraging categorization
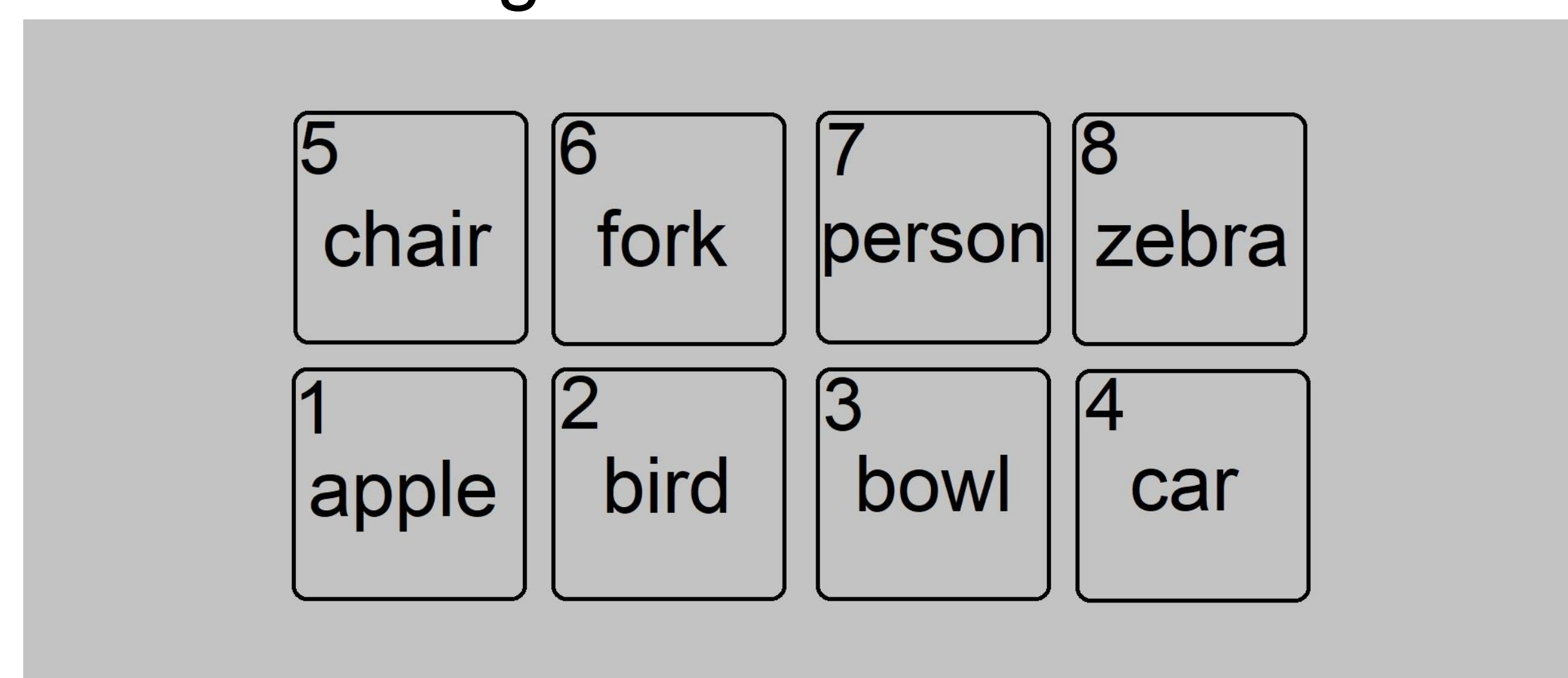2) local complexity or distance from fixation

Basic Task:
Is probe dot "on" or "off" object at nearest contour?

Fixation Cross (until foot pedal press)

Target 100 ms
(Probe Dot Flickers on/off at 50 Hz)

Mask[5] 200 ms

Until Response or 3000 ms

Tasks

Task 1: Basic Task Only

Task 2: 8 AFC Categorization Task after Basic Task

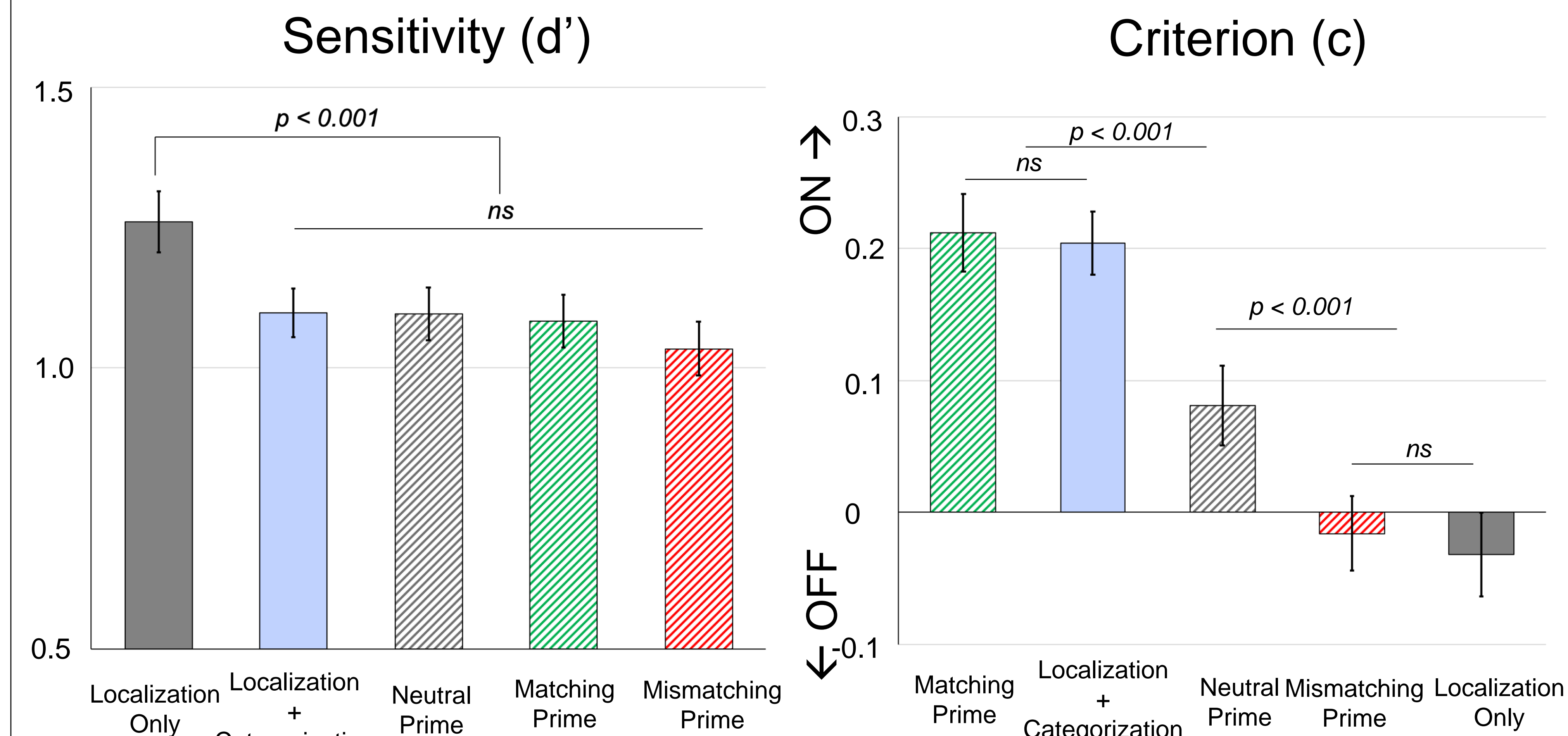| 5 chair | 6 fork | 7 person | 8 zebra |
| 1 apple | 2 bird | 3 bowl | 4 car |

Task 3: Word Before Basic Task Basic Task Sequence

300-ms unmasked word prime & 100-ms ISI

Neutral: XXXXXX → Bird
Matching: bird   → Bird
Mismatching: fork   → Bird

(different superordinate category)

Task affected sensitivity and criterion

Sensitivity (d')

$p < 0.001$

ns

Localization Only | Localization + Categorization | Neutral Prime | Matching Prime | Mismatching Prime

Criterion (c)

ns $p < 0.001$

$p < 0.001$

ns

Matching Prime | Localization + Categorization | Neutral Prime | Mismatching Prime | Localization Only

Detection sensitivity lower when target categorization was required (Task 2) or encouraged by presence of prime (Task 3)
    Due to interference from categorization or increased load[6]?

"On" responses increased in Task 2 (with categorization task) & in the matching prime condition of Task 3
    Increased likelihood of improved categorization from matching prime or categorization task facilitated reporting dot as "on"
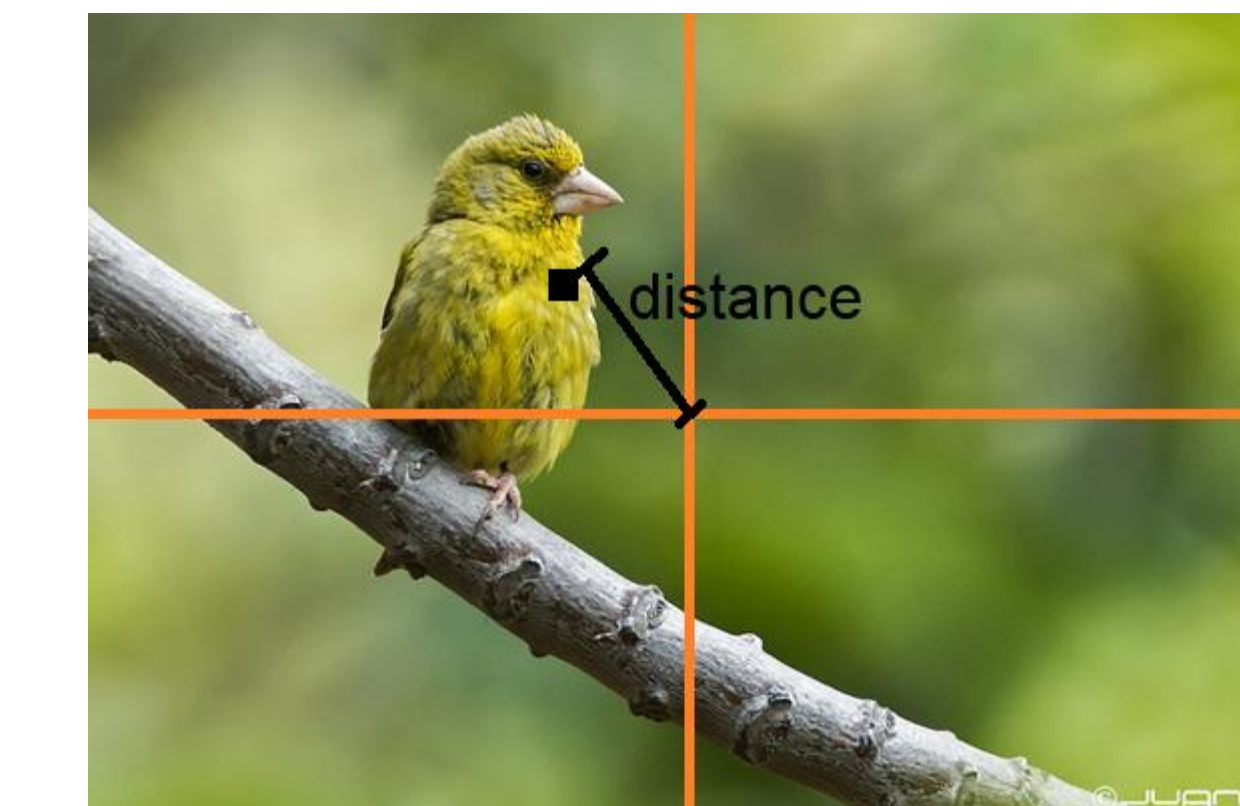
Image Characteristics

Local Complexity: Proportion of border pixels detected (using a Canny filter) within 2° of the contour nearest to the dot probe

No effect of Local complexity on detection sensitivity
    ps > 0.10

Criterion increased with complexity
(with more nearby borders, Ps reported "on" more often)
    Significant in 4 of 5 tasks (all but Task 2): r's: 0.133 – 0.170 ps < 0.01

Distance: distance from center of image to the contour nearest to the dot probe

Sensitivity decreased with distance from the center in all task conditions
(r's: 0.373 – 0.412, ps < 0.001)
    Expected since resolution decreases with distance

Criterion also decreased with distance
Ps were less likely to say "on"
(r's: -0.100 – -0.481 ps < 0.05)
    P's became more conservative as distance increased

Discussion

Our goal is to conduct a comprehensive analysis of object detection including both top-down and bottom-up factors
    Create predictive model including both task conditions and image characteristics

Next step: enter these factors into predictive model to see how weights are affected by their interactions

References

[1] Lin, T. Y., et al., (2014). Microsoft coco: Common objects in context. In *European Conference on Computer Vision*, pp. 740-755.

[2] Flowers, C., & Peterson, M. (2018). Human Object Detection in Natural Scenes: Evidence From a New Dot Probe Task. *Journal of Vision, 18*, 393-393.

[3] Flowers, C. S., Skocypec, R. M., & Peterson, M. A. (2019). Does Semantic Activation Affect Human Object Detection in Natural Scenes?. *Journal of Vision, 19*, 58a-58a.

[4] Greene, M. R., Baldassano, C., Esteva, A., Beck, D. M., & Fei-Fei, L. (2016). Visual scenes are categorized by function. *Journal of Experimental Psychology: General, 145*, 82.

[5] Portilla, J., & Simoncelli, E. P. (2000). A parametric texture model based on joint statistics of complex wavelet coefficients. *International journal of computer vision, 40*, 49-70.

[6] Lavie, N., Hirst, A., De Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of experimental psychology: General, 133*, 339.

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