Testing a prediction of the central-peripheral dichotomy in visual inference: visual backward masking is weaker in the peripheral visual field

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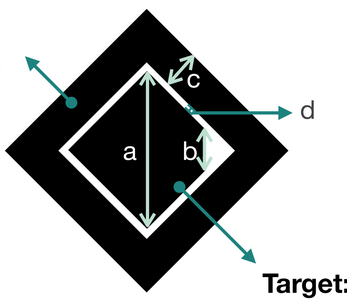
Introduction

What is visual backward masking?

Backward masking is the reduced visibility or discriminability of a brief object, the target, when a mask is presented shortly afterwards. This masking is particularly strong for metacontrast masking, when the contours of the mask and target are easily confused with each other. Target discrimination is worst when the mask onset around 40 to 100 ms after the target onset, this onset time difference is the **stimulus onset asynchrony** (SOA).

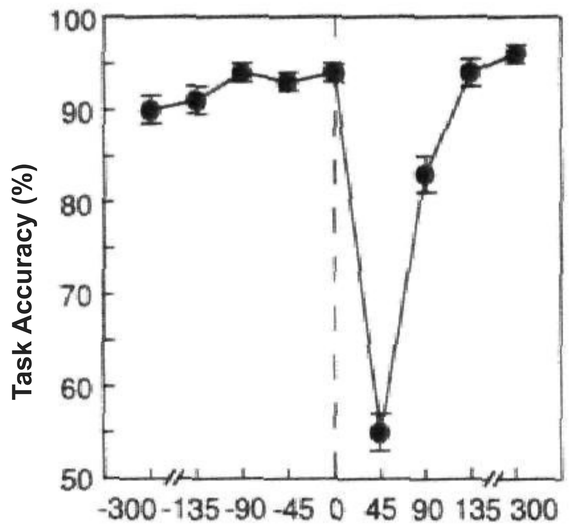
Mask: the diamond frame



Arrows and letters are not parts of the stimulus

Task: report whether the left or right corner of the target is missing

Target: the solid diamond missing its right (or left) corner



SOA (ms): Mask onset time - target onset time

Results from Enns and Di Lollo (1997) when the target was at the fovea.

Motivation

- Because masking is strongest at SOA>0 (around SOA ~50 ms), it is believed to be caused by a conflict between feedback signals about the target and feedforward signals from the trailing mask. Meanwhile, others (Macknik & Martinez-Conde 2017) have argued that mainly feedforward mechanisms are responsible.

  from higher to lower visual areas in the brain

- Zhaoping (2017, 2019) proposed that top-down feedback for object recognition is weaker in peripheral vision, since object recognition is mainly done by central vision.
- If backward masking is mainly caused by the feedback mechanisms, then

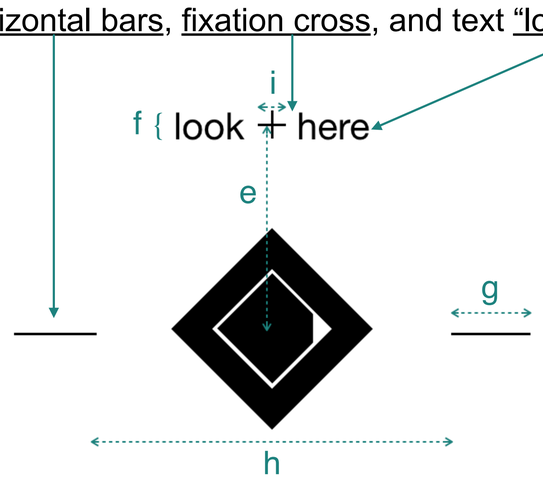
➡ **Prediction:** backward masking becomes weaker for larger eccentricities.

➡ **Our approach:** A psychophysical experiment to test this prediction, using various target-mask stimulus onset asynchronies (SOA) and target viewing eccentricities: 1°, 3°, 9°.

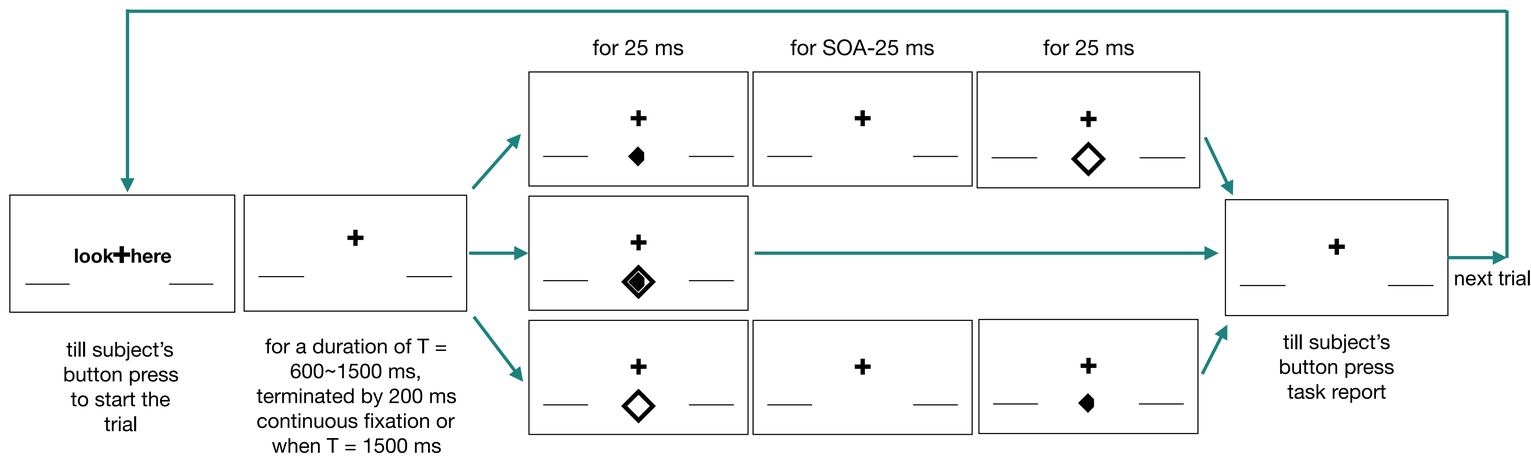
Experimental design

Modifications from Enns and Di Lollo (1997),

1. Centre of target/mask position fixed across trials on the display;
2. Two horizontal bars, fixation cross, and text "look here" added;



3. Sizes of all stimulus elements (target, mask, fixation cross, etc), and the eccentricity (e) of the target centre (from the fixation cross), varied randomly across trials, scaled by the eccentricity;
4. Two horizontal bars: markers for the target's vertical location;
5. "look here": flanking the fixation cross, served to tell subjects where to fixate for each trial.



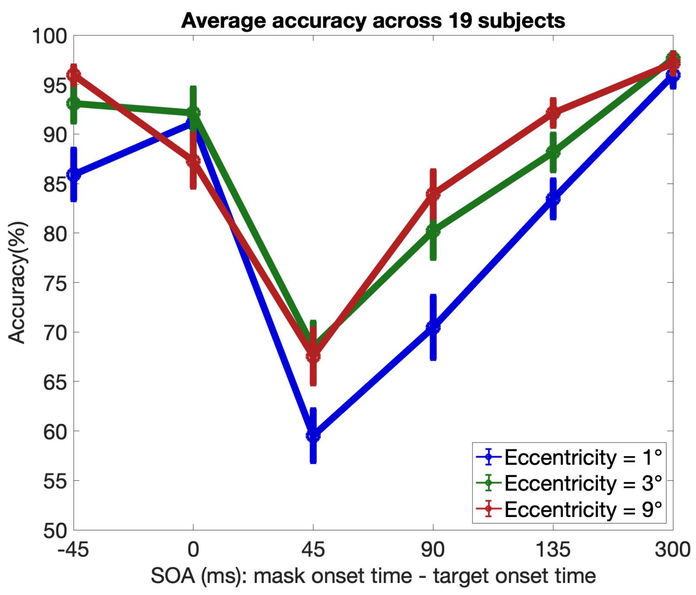
Sizes of stimuli for eccentricity 1°, 3°, 9° (e)

e	a	b	c	d	f	g	h	i	Line width in bars and cross
1°	0.62°	0.17°	0.20°	0.02°	0.12°	0.36°	2.00°	0.12°	0.03°
3°	1.55°	0.43°	0.50°	0.05°	0.30°	0.90°	5.00°	0.30°	0.08°
9°	4.34°	1.19°	1.40°	0.14°	0.84°	2.52°	14.00°	0.84°	0.21°

Gaze tracked by eye tracker throughout the trial, fixation at cross is defined as when gaze is within 1.5° from the centre of the cross.

Invalid trial: T= 1500 ms.

Result



- 23 subjects participated , 4 subjects were excluded because over 10% of his/her trials were invalid

P - Values

SOA (ms)	1° vs. 3°	1° vs. 9°	3° vs. 9°
-45	0.004(**)	0.006(**)	0.333
0	0.797	0.237	0.079
45	<0.001(***)	0.005(**)	0.768
90	<0.001(***)	<0.001(***)	0.113
135	0.020(*)	<0.001(***)	0.046(*)
300	0.142	0.360	0.553

- $H_0 : \text{Accuracy}_{E=9^\circ} = \text{Accuracy}_{E=3^\circ} = \text{Accuracy}_{E=1^\circ}$
- $H_\alpha : \text{Accuracy}_{E=9^\circ} \neq \text{Accuracy}_{E=3^\circ} \neq \text{Accuracy}_{E=1^\circ}$
- Each p-Value is calculated via paired-sample t-test

Conclusion

- When eccentricity is 3° or 9°, backward masking is significantly weaker than when eccentricity is 1°, as predicted by Zhaoping 2019.
- Backward masking is strongest at SOA = 45 ms at all three eccentricities.
- Masking is stronger for SOA>0, consistent with the idea that feedback mechanisms are mainly responsible.
- However, backward masking was observed for all three eccentricities, suggesting that feedback at 3° and 9° is still present, but is just weaker.
- Not yet clear from current data whether the masking at 3° is weaker than that at 9°.

Outlook

- Whether a visual phenomenon is stronger or weaker at larger eccentricities could be used to probe whether the brain mechanisms responsible involve mainly feedforward or feedback processes (Zhaoping 2019). For example, reversed depth perception is stronger at periphery (Zhaoping & Ackermann 2018), manifesting feedforward reversed depth signals from V1.
- Whether and how the maskings at 3° and 9° eccentricities differ needs further study.
- Join us if you are interested! www.lizhaoping.org

References

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