Exploring Visual Perception in the Praying Mantis

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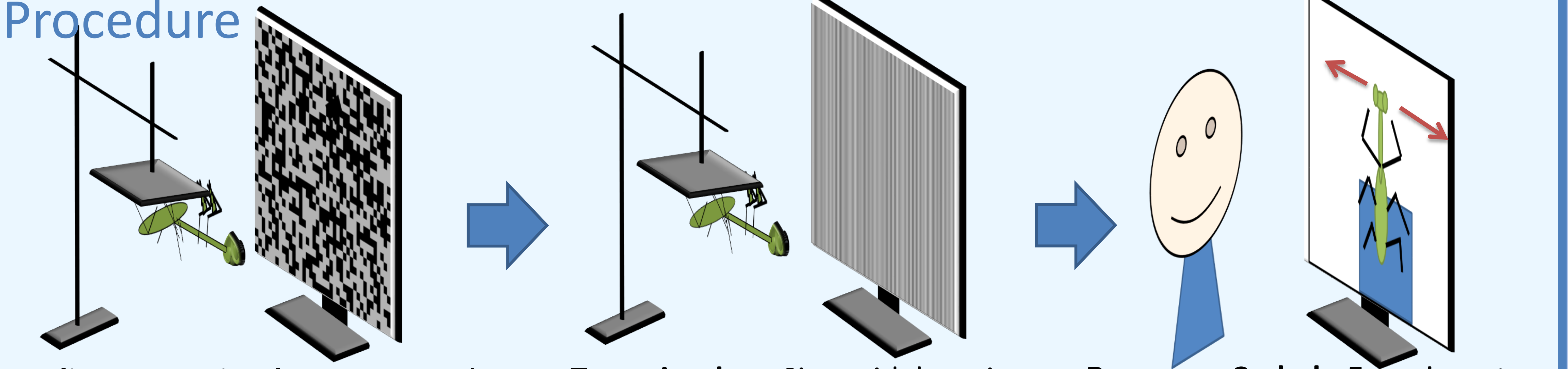
Background

- The **praying mantis** is a predator that tracks and strikes at specific prey types based on several cues including motion
- Motion detection is a fundamental cue that enables the sophisticated level of predation we see in the praying mantis
- Little is known about the mechanisms underlying motion detection in this insect
- The **optomotor response** of the mantis has remained largely uncharacterized

Aims

- Investigate the **contrast sensitivity** function in the praying mantis *Sphodromantis lineola*
- Investigate how the contrast sensitivity depends on **spatial and temporal** frequencies of the background
- Investigate how the dependency of this sensitivity on the spatio-temporal frequencies of the background related to the **behavioural ecology** of the mantis.
- Investigate the **optical and anatomical eye features** responsible for mantids contrast sensitivity

Procedure



Alignment stimulus - Attracts the mantis and centres gaze

Test stimulus - Sinusoidal grating filling the entire screen that either moved right or left for 5 seconds

Response Coded - Experimenter codes whether mantis moves left, right or fails to respond.

Experiment 1

- In each trial of the experiment, the grating could vary in two characteristics: contrast and spatial frequency
  - Seven different contrast levels *(1, 0.5, 0.25, 0.125, 0.0625, 0.03125 and 0.015625)*
  - Nine different spatial frequencies *(*0.000625, 0.00125, 0.0025, 0.005, 0.01, 0.014925 , 0.02, 0.04, 0.083333 c/px)
- The temporal frequency was fixed at 8Hz as it produced the highest peak response values is previous experiments
- Each mantis faced an average of 2304 trails across 9 runs

Results

- With increasing contrast the probability of responses increased until it reached a maximum value. Beyond this value, greater contrast did not increase the probability of response. The 50% response threshold varied with the different spatial frequencies.
- Increasing spatial frequency led to an initial increase in the response sensitivity until a peak sensitivity after which there was a decrease in sensitivity.
- Mantises were most sensitive to relatively higher temporal frequencies, indicating that mantis are sensitive to relatively higher velocities of moving in their environment. (See Fig. 2)

Conclusions

- Our results show that the optomotor response in the mantis is a reliable behaviour that can be used to investigate its visual capabilities as has been done in other insects.
- The contrast sensitivity of the mantis appears to differ from those of primates, fast-flying insects and hovering insects. The uniqueness of the mantis contrast sensitivity function probably reflects its visual ecology and specialization as an ambush predator on fast-moving prey.

Experiment 2

- In each trial of the experiment, the grating could vary in three characteristics: contrast, spatial frequency and masking.
  - Six different contrast levels *(0.5, 0.25, 0.125, 0.0625, 0.03125 and 0.015625)*
  - Two different spatial frequencies *(low and high: 0.04 and 0.2 c/deg)*
  - Three different masking conditions *(see Fig. 1)*
- Each mantis faced 720 trials across 2 runs

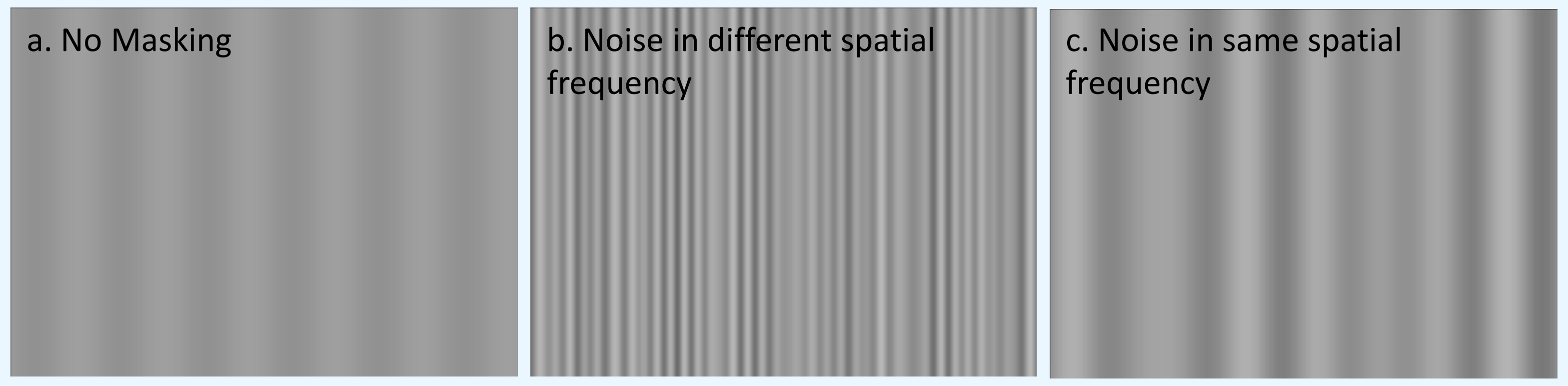


Fig 1. Three different masking conditions at SF=0.04, Contrast=0.0625

Results

- A high and low frequency signal is equally visible in absence of noise
- A high and low frequency signal is equally visible when the noise is at the same spatial frequency
- High and low frequency are not equally visible when the noise is at a different spatial frequency.
- Low frequency noise affects mantids ability to detect high frequency signal; however, high frequency noise does not effect mantids ability to detect low frequency signal. (See Fig. 3)

Conclusions

- The results of Exp. 2 lead to suggest that mantids have two or more spatial frequency channels.
- We hypothesize that there are two channels, one low-pass one that can see only the low frequency signal, and a broad-band one that can see both low and high.
- When there is a low frequency signal with high frequency noise, the low-pass channel can perform as well as usual since it cannot see the high frequency noise. But to detect the high frequency signal, mantids must use the broad-band channel, and that is affected by noise at both low and high frequency.

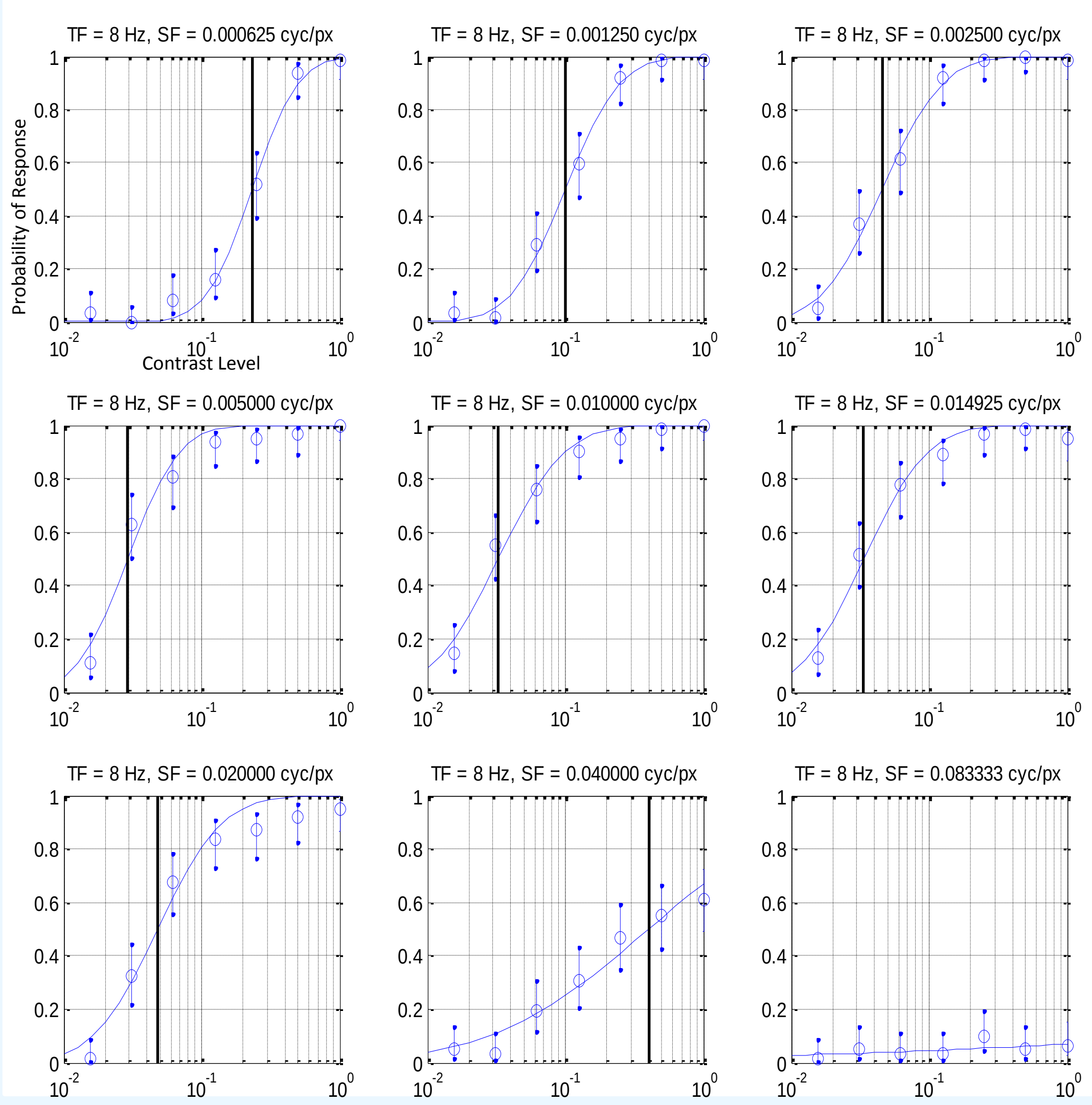


Fig 2. Probability of correct response as a function of stimulus contrast, for different spatial frequencies presented at 8Hz.

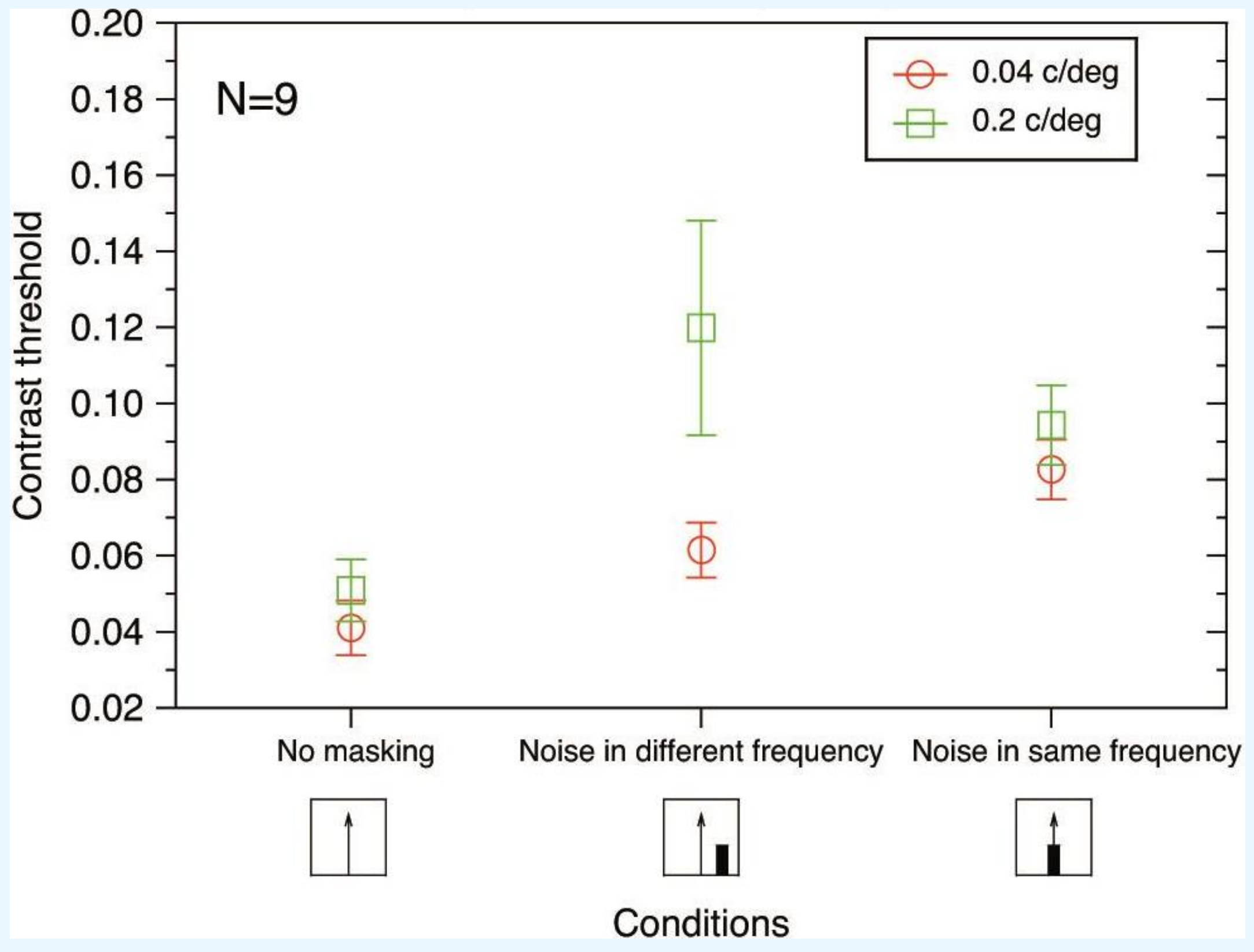


Fig 3. Contrast thresholds during three masking conditions

Fig 4. Sphodromantis lineola

Directions for Future Research

- The two channels deduced from the data may be a result of differences in the way the ommatidia filter the light in different regions of the eye.
- We suggest mantis blur light using a Gaussian filter whose radius reflects the ommatidia.
- We hypothesize that the results of Experiment 2 can be explained by small ommatidia in the fovea producing a broadband low-pass filter, and the large ommatidia in the periphery producing a narrower-band low-pass filter.
- To test this theory we have begun experiments using occluders to block out either the periphery or the centre of the mantis visual field and will retest mantis using the stimuli from Exp. 2.

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