How does the Praying Mantis Detect Motion in Depth?

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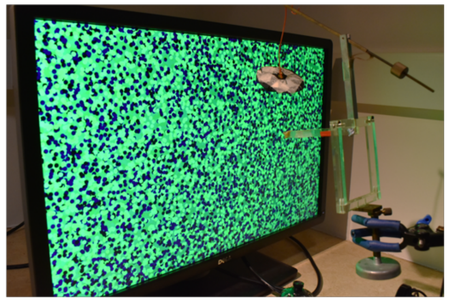
1) Introduction & Aim

- **Looming** is the apparent increase in size of an approaching object in the visual field of a viewer and is an important visual cue used to detect motion in depth
- Remarkably for an invertebrate, the praying mantis possesses stereo vision[1], so we ask 'how does looming combine with stereo cues to depth?'
- An **insect 3D cinema** setup[2] was used to investigate the specific visual cues that the African Mantis (*Sphodromantis Lineola*) uses to detect motion in depth (change in disparity & looming)

2a) Methods

- "3D glasses" made of red and blue filters were attached to the mantids with beeswax and rosin
- The mantis was attached upside down to a holder at a viewing distance of 10cm from a screen
- Stimuli coded with the MATLAB Psychophysics toolbox were presented in a random order
- Strikes were recorded with a webcam then played back and manually coded by an observer
- 2 runs of 32 stimuli each were run on each mantis (n =14)



Mantis with 3D 'glasses' and the experimental setup

for each stimuli, the target was…

- …a patch of dots that spiralled in from the periphery to the centre of a random-dot background
- …indistinguishable from the background in any one frame, but was only made visible due to its motion
- Its disparity indicated it approached from an initial distance of 20cm to a final distance of 2.5 cm (in mantis catch range)
- The target was defined by one of four different conditions:
  - either one of **Flow** or **NoFlow** (optic flow stimuli) in combination with..
  - either one of **Loom** or **NoLoom** (size stimuli)

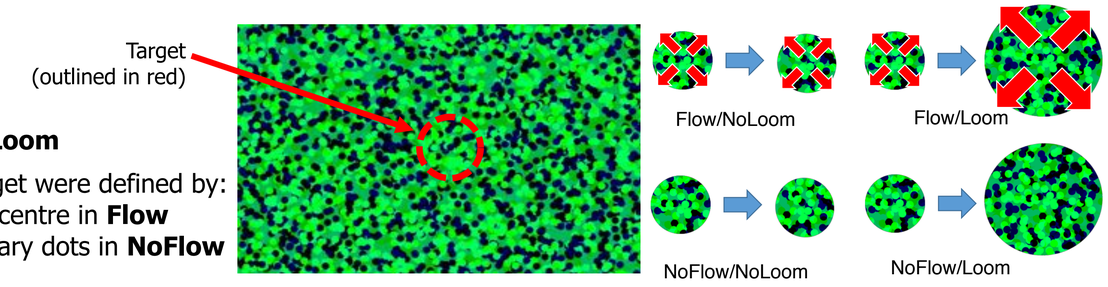
2b) Stimuli

Size Stimuli. The size of the target:

- Increased as it spiraled inwards in **Loom**
- Was constant as it spiraled inwards in **NoLoom**

Optic Flow Stimuli. The borders of the target were defined by:

- Centrifugal movement of dots from target centre in **Flow**
- Concurrent addition and removal of boundary dots in **NoFlow**



3) Results & Discussion

Figure 1: Mean Number of Strikes to Looming and Constant Size Stimuli

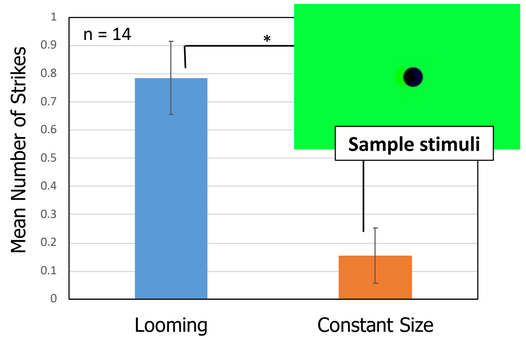


Figure 2: Mean Number of Strikes per Condition

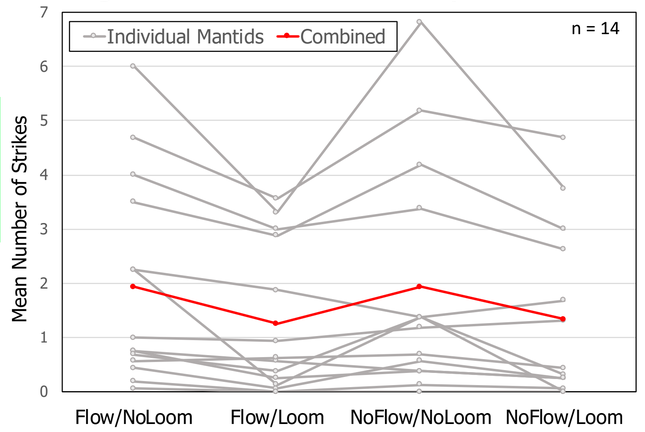
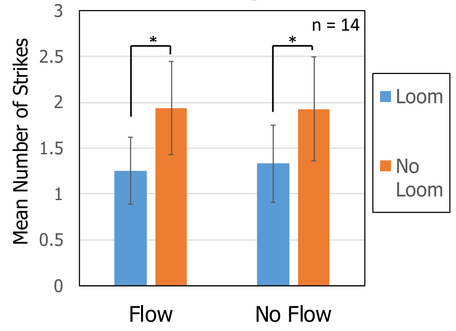


Figure 3: Combined Mean Number of Strikes per Condition



In a previous experiment, mantids responded significantly more to a stimuli with looming compared to stimuli of a constant size (Fig 1) The stimuli was a black circle on a plain green background (inset) presented to mantids (n = 14) in a similar fashion to this experiment.

In the current experiment, optic flow had no significant effect on mantis strikes, whereas conditions with No Looming elicited significantly more strikes than conditions with Looming (Fig 2). This difference was significant both in conditions with optic flow and without optic flow (Fig 3). This initially appeared to contradict the results of the previous experiment.

However, in the previous experiment the target was defined by a border with high contrast (black on green background), whereas in the current experiment the target was defined by a border with low contrast (dots in motion). The high contrast target could be easily be discriminated from the background, increasing the attractiveness of the target to the mantis. Conversely, it was more difficult to discriminate the borders of a low contrast target from the background. The change in size over time of the Loom stimuli would have exacerbated this difficulty, decreasing the attractiveness of Loom stimuli as compared to NoLoom stimuli.

4) Conclusions

- The Looming cue enhances strike rate for a stimulus with a high contrast luminance boundary, whereas it reduces strikes for stimuli defined by temporal change
- The praying mantis appears to use **the radial motion of a luminance edge** as the main visual cue to detect looming objects
- Neither optic flow nor changing size are important in the detection of looming

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References:

1. Rossel S. Binocular stereopsis in an insect. Nature. 1983;302:821.
2. Nityananda V, Tarawneh G, Rosner R, Nicolas J, Crichton S, Read J. Insect stereopsis demonstrated using a 3D insect cinema. Scientific Reports. 2016;6:18718.