Integration of Monocular Cues in Depth Perception of Short-horned Grasshopper

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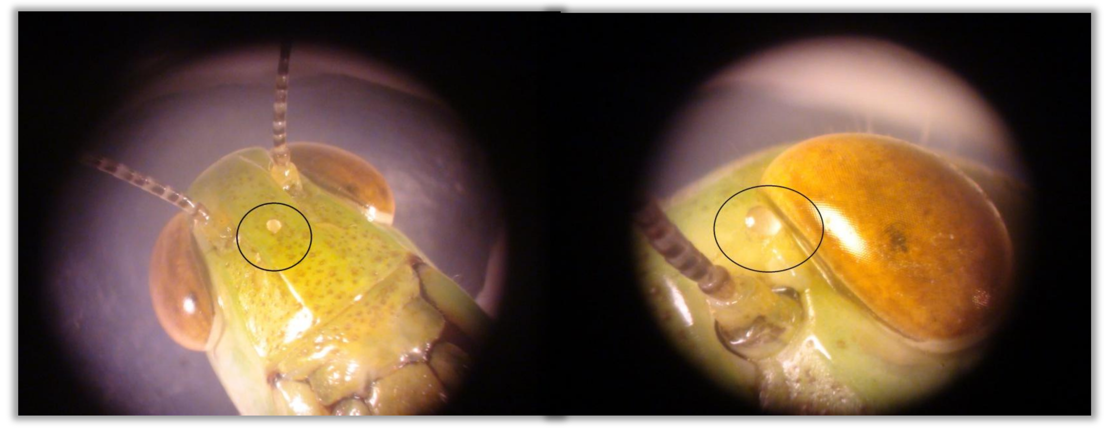
INTRODUCTION

Short-horned grasshoppers (family *Acrididae*) are agile insects that show interesting visual responses. These insects are adapted to accurately gauge depth and evade predators by swiftly jumping through grassy patches.

Short-horned grasshopper

The grasshopper visual system consists of two **compound eyes** and three simple eyes(the ocelli). The compound eyes are made up of numerous visual cells known as ommatidia which collectively form images, while the ocelli provide information about the ambient light intensity.



Compound eyes (ocelli circled)

The compound eyes are far apart on the head providing a large monocular field of vision, as expected for an organism that needs to keep track of approaching predators. A small portion of the visual field is binocular wherein the visual fields of both compound eyes overlap. To accurately calculate the depth of an object that exists beyond the binocular field of vision the grasshopper relies on **motion parallax**.
As an observer moves the objects that are nearer move farther across the field of vision than do objects that are at a distance, this phenomenon is known as motion parallax. By moving its head about its body axis in what is known as **peering behavior**, the grasshopper exploits motion parallax to compute object distances. Each eye carries the retinal image disparity information resulting from the head movement, which is then used to compute the distance of an object .

OBJECTIVES

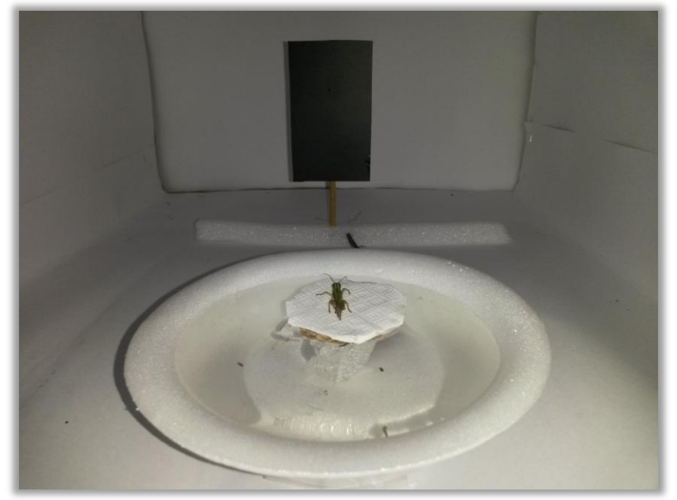
- Determine how and whether the inputs from both the eyes are used to compute the object distance. Since even one eye should be sufficient to provide information about the distance of the object.
- Study the effect of occlusion of one eye on the peering behavior of the grasshoppers.
- Determine the relation between the peering amplitude of normal grasshoppers versus the insects having only monocular cue.

METHODS

- Wild grasshoppers were caught in plastic containers and were fed fresh grass blades three times a day. To temporarily blind the eye, a coat of Fevicol™ was applied on the eye. A coat of black ink was applied using Cello™ black gel pen on the dried fevicol coat to prevent any light from entering the eye.

Apparatus

- The apparatus is a cardboard box of base dimension **45X70cm** and height **35cm** with all the inside surfaces covered with white paper. A circular platform of diameter **4.5cm** is placed in a container which is filled with water. A black cardboard piece of dimension **10X6cm** is used as a stimulus which is placed vertically on a movable platform and set at specific distance from the circular platform.

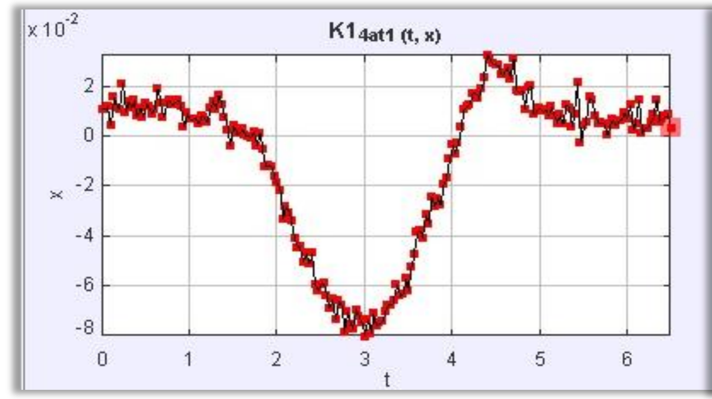


View from behind the animal

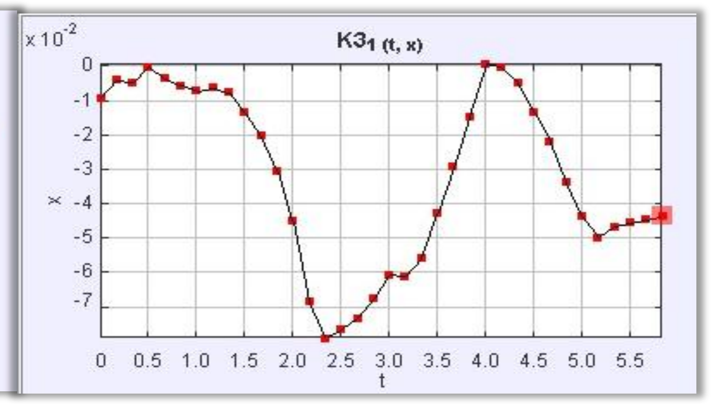
Motion is recorded from above

- The insect is placed on the platform slowly using a stick. When introduced to novel environment, the insect spontaneously peers repeatedly at the target since it prefers looking at contrasting edges. To induce peering, the insect can be poked gently with a stick. Video camera is placed directly above the insect which records its motion. The peering motion is then characterized using these videos.
- The videos were analyzed using the open source Tracker Video Analysis and Modeling Tool. Peer amplitude was calculated for all the peers exhibited.
- A total of two insects were studied for two distances of 15cm and 30cm from the platform. The study was repeated for each animal after occluding one of its eyes with the black layer.

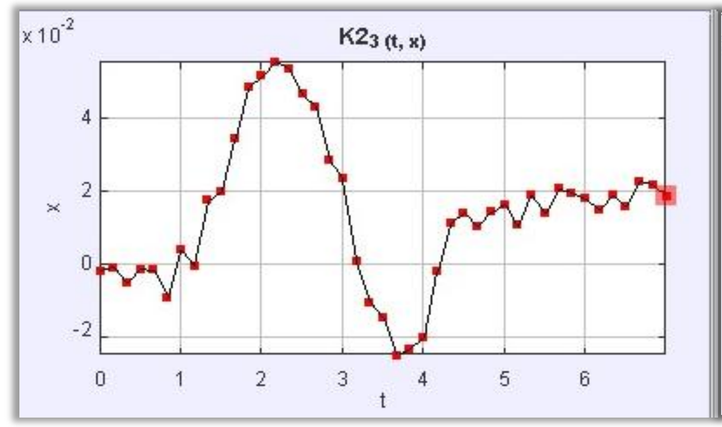
RESULTS



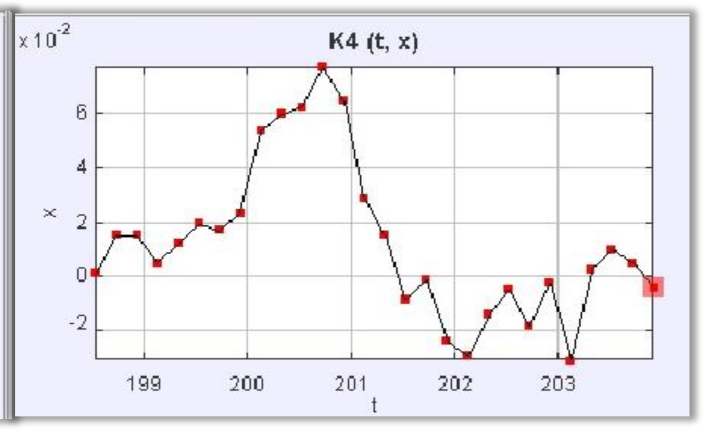
K 1- Animal A | 15cm | Binocular



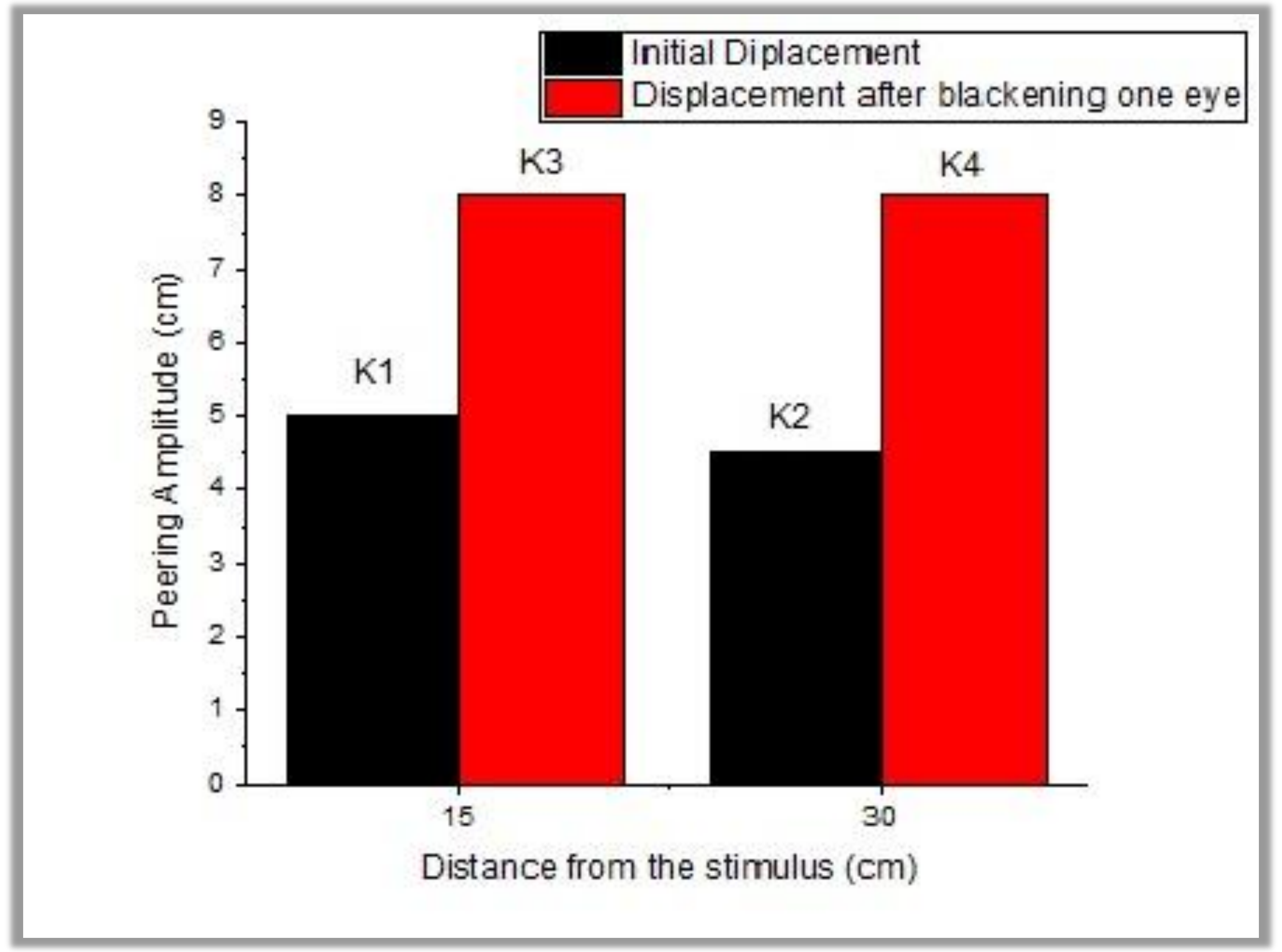
K 3- Animal A | 15cm | Monocular

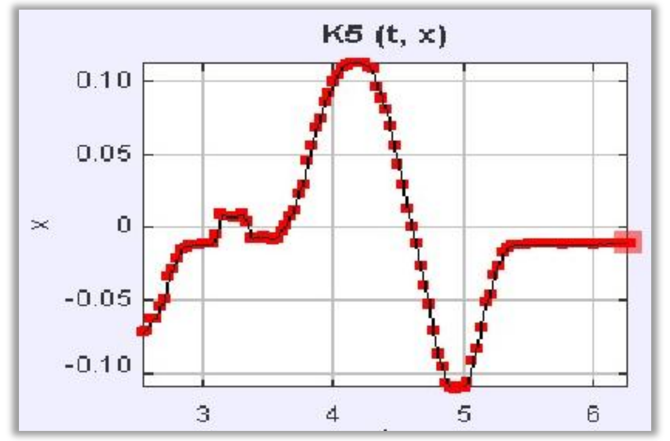


K 2- Animal A | 30cm | Binocular

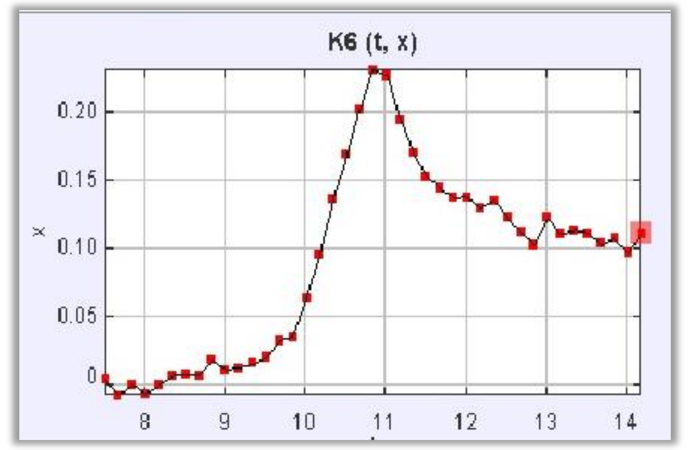


K 4- Animal A | 30cm | Monocular

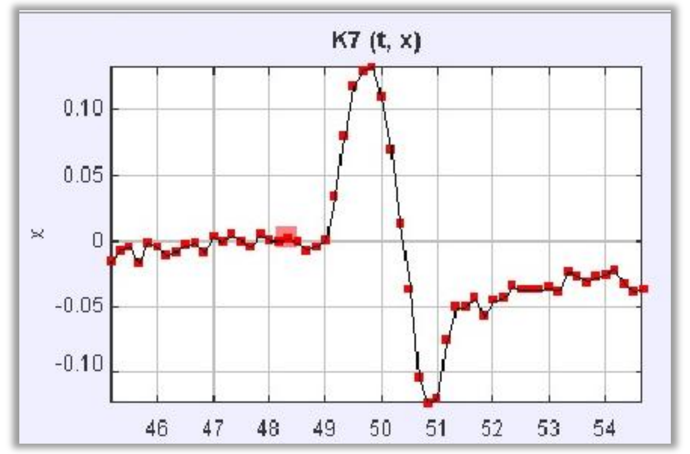




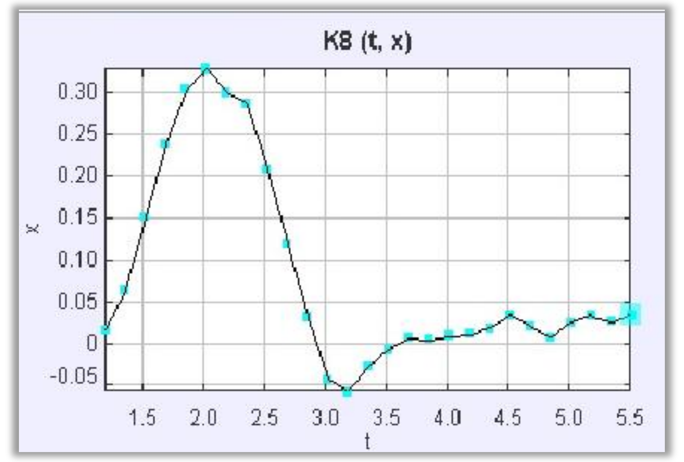
K 5- Animal B | 30cm | Binocular



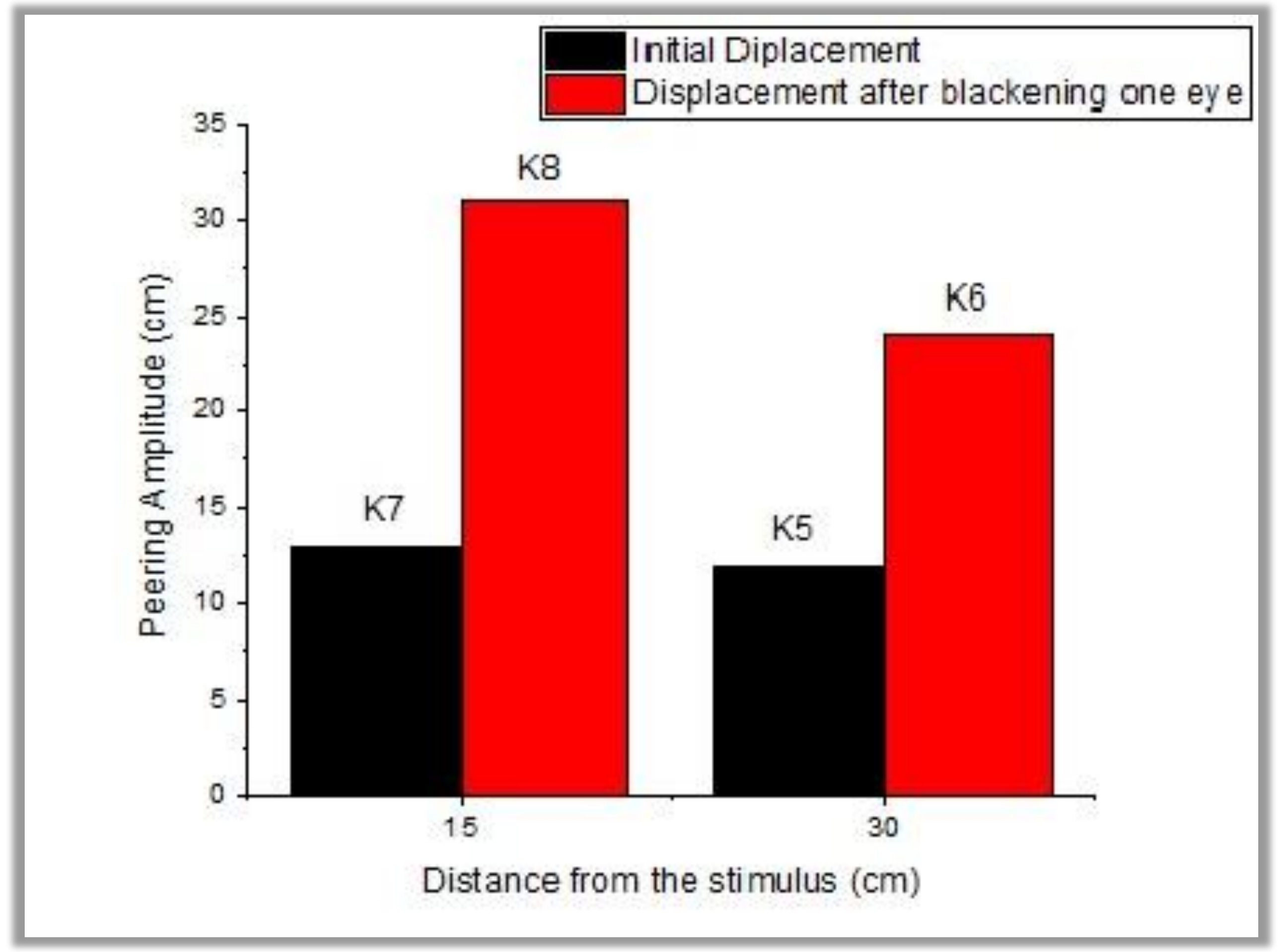
K 6- Animal B | 30cm | Monocular



K 7- Animal B | 15 cm | Binocular



K 8- Animal B | 15cm | Monocular



CONCLUSIONS

- In the insects with one eye occluded, the peering was more towards the side that was opposite to the side of occluded eye.
- The peer amplitude increased by twofolds in the insects with one eye occluded, suggesting that the inputs from both the eyes are simply averaged, that determines the peer amplitude of the insect. Further experiments are needed to ascertain how exactly this computation is done by the grasshopper.

ACKNOWLEDGEMENTS

- We are thankful to Prof. Amit Mukherjee for his valuable inputs and constant guidance.
- We are gratefull to Dr. Nitin Gupta, BSBE, IIT Kanpur for his inputs on the project and for providing us with the lab space.

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