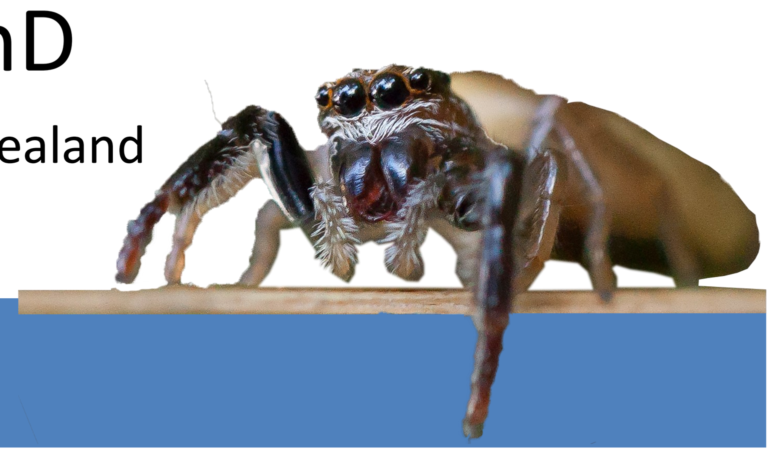
Depth from defocus: plasticity in the New Zealand jumping spider eye?

Aimee Aitken, John Phillips, PhD & Phil Turnbull, PhD

Myopia Laboratory, School of Optometry and Vision Science, The University of Auckland, New Zealand

Contact: aait601@aucklanduni.ac.nz

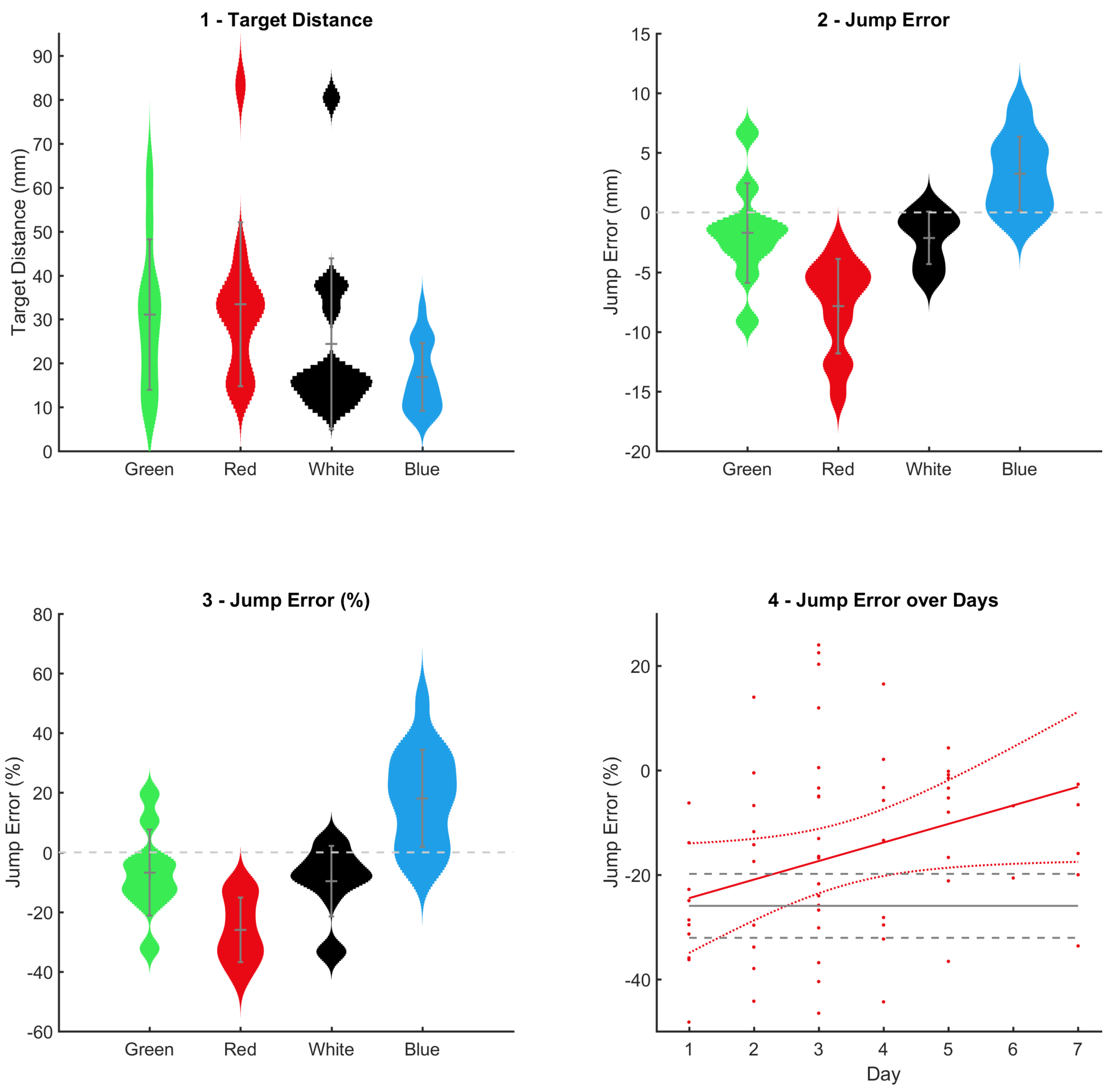


AIM

How the eye detects the sign of retinal defocus is unknown, but an important first step in the process of emmetropisation. The principal camera-type eyes of jumping spiders have a layered retina, with one layer containing green (535nm) sensitive visual pigment, and another layer sensitive to red (626nm). It has been suggested that this layered structure allows computation of target distance (depth) by comparing the relative image defocus between layers. We investigated how moving the focal plane with different lighting spectrums affected the spiders jumping accuracy. A second experiment investigated whether the spiders could adapt their behaviour to a change in focal conditions, observed by an improvement in jumping accuracy.

RESULTS

- Under red light spiders jump ~27% shorter than green ($p = .003$) and white ($p = .006$) light (Figures 1-3).
- Under blue light spiders jump ~18% further than under green light ($p = .018$).
- There was no difference in jump accuracy between spiders under green and white light ($p = .841$).
- Jump error reduced over 7 days of constant red light exposure compared to non constant exposure ($p = .044$, Figure 4).
- Jump error reduced by approximately 3.8% each day.



Figures: Target distance (Fig 1), jump error in mm (Fig 2) and proportional jump error (Fig 3) in the four different chromatic environments. Plot width represents frequency, solid grey lines are group means with +/- standard deviation. Dashed grey line shows zero. Negative values represents an under jump relative to target distance, and positive values are an over jump. Figure 4 shows the change in proportional jump error of spiders under seven days of red light exposure (red lines), compared to mean jump error without adaptation (grey lines).

METHODS

- 19 NZ jumping spiders *T. planiceps* were kept under broad spectrum white light and were transferred to either green (520nm), red (620nm), or blue light (465nm) for feeding.
- Spiders were offered Drosophila fruit flies up to three times daily, and their jumps were recorded and analysed.
- Jump error was taken as target distance - jump distance, and then calculated as a proportion of target distance.
- Spiders were then left under red light for 7 days to assess if they could adapt their behaviour under red light.

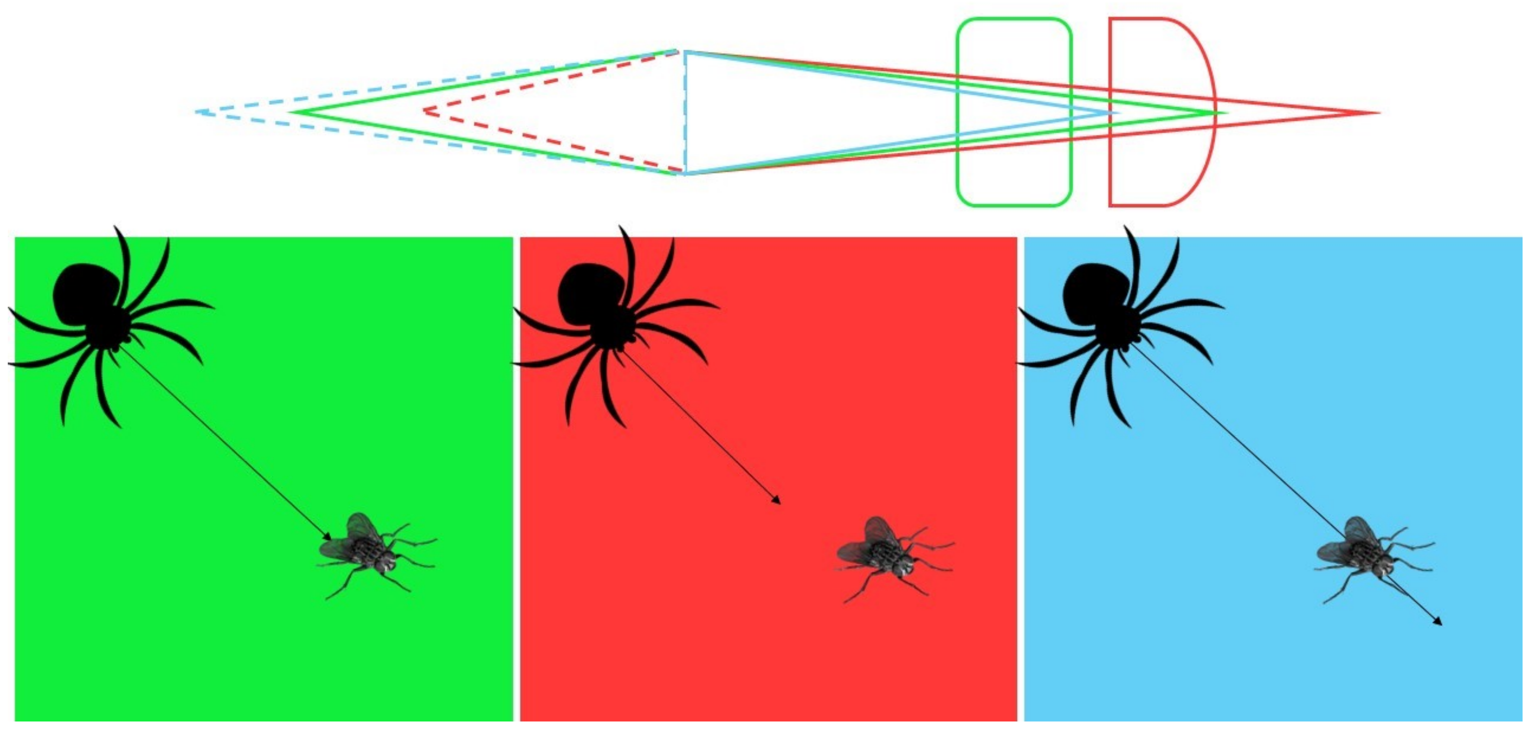


Figure 5: Under broad spectrum lighting, chromatic aberration in the spider eye creates different amounts of defocus on the red and green sensitive retina (solid lines). Under pseudo-monochromatic light, retinal defocus gives the appearance that the target is closer or further away (dashed lines). Under green light, this results in an accurate jump. Under red, the spider underestimates target distance (an under jump) while under blue, it overestimates target distance (an over jump).

CONCLUSION

- Retinal image defocus appears to provide cues for depth perception in *T. planiceps*.
- Chromatic aberration can be used to manipulate focal plane, and can be seen as a change in jump error.
- Behavioural plasticity was observed in *T. planiceps,* as jump error reduced over a 7 day adaptation period.
- Further research is needed to identify if this plasticity is occurring within the eye (emmetropisation) or at the level of the brain (neural plasticity).

Disclosure: The primary researcher was granted a Summer Research Scholarship by the University of Auckland.