Phototactic escape reflex in *Caneorhabditis elegans* is inhibited at high frequency of wave speed

KEVIN DONOHUE, SE YOUNG LEE, SYED HYDARI, NEIL MAITHEL, Joseph Thatcher, Ahis Shrestha, Javier Carmona, Suying Jin, Steve Mendoza, Blake Madruga, Shayan Niaki, Richa Raghute, Anthony Baldo, and Katsushi Arisaka

UCLA, *Elegant Mind Club* @ Department of Physics and Astronomy

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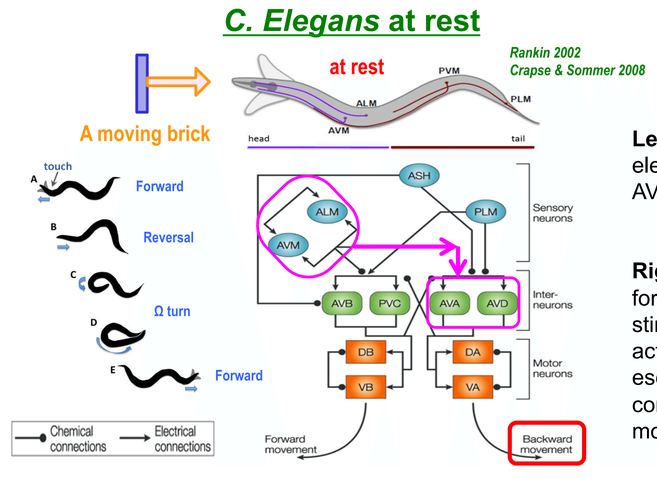
ABSTRACT

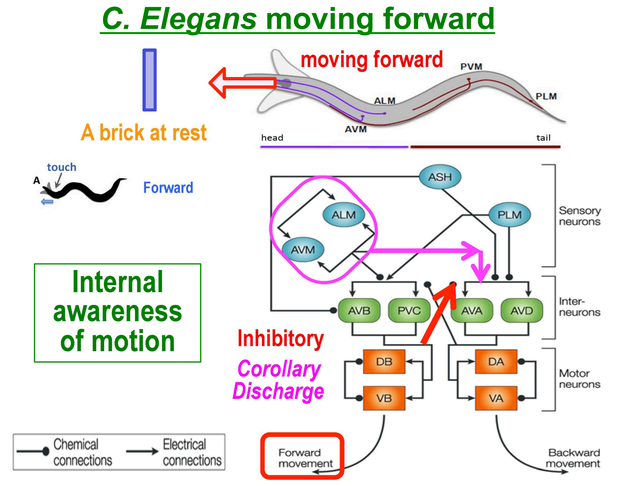
- Self-regulation of motion is a necessary behavior for any motile heterotrophe[1], but the mechanisms underlying the interactions between different behavioral drives is poorly understood[2,3].
- To elucidate this mehcanism, we look at the networks of forward and backward motion in *Caenorhabditis elegans*, which interact with each other to regulate escape reflexes.
- Based on the neural network regulating this interaction[4], we hypothesize that specimens moving at high frequency oscillatory speeds will have inhibited escape reflex due to corollary discharge from the forward-motive interneurons AVB and PVC on backward-motive interneurons AVA and AVD.
- In order to test this response, we compare phototaxive escape reflex[5] between worms moving at different wave speeds in order to determine whether this simple organism is capable of rudimentary awareness of its own motion.

OUR MODEL: ORIGIN OF PERCEPTION OF OWN MOTION

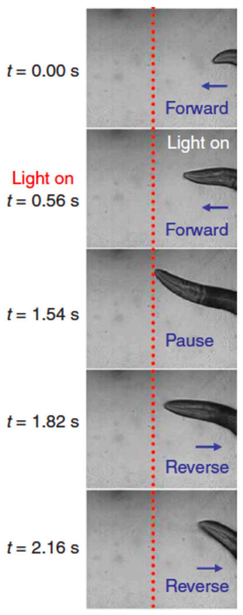


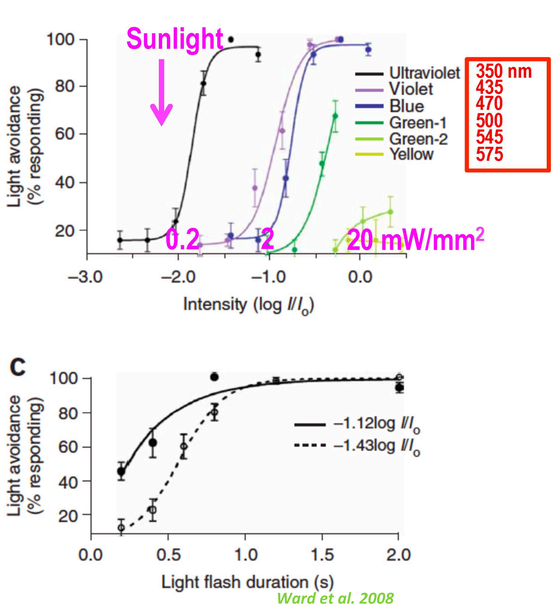
Left; Classical escape reflex in C. elegans is mediated by the AVA and AVD interneurons.

Right: Hypothetical model where forward motive pathways act to inhibit stimulation of reversal motive pathways acting to attenuate the initiation of escape reflex when the worm is motile, constituting a rudimentary level of motion awareness.



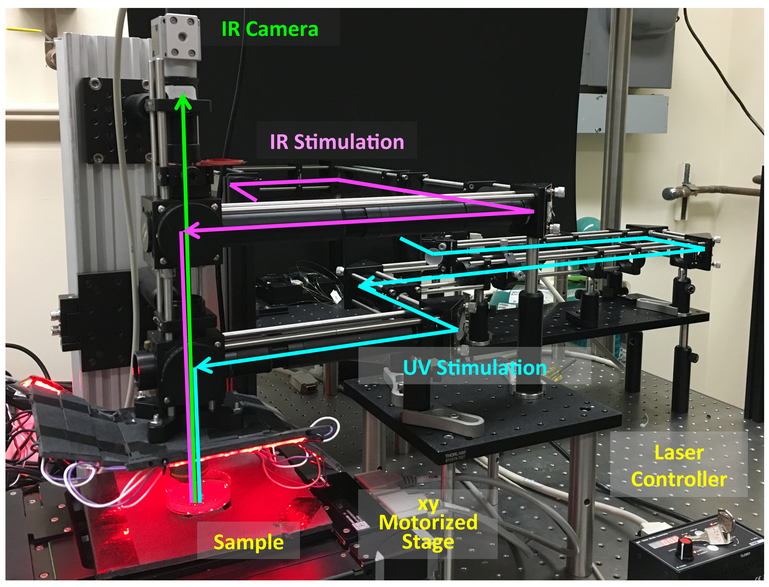
REPORTED PHOTO AVOIDANCE BEHAVIOR





Phototaxive escape reflex is a dose dependent process that is facilitated by high frequency light, as elucidated by Ward et al. (2008). As characterized by previous research, a full escape reflex is characterized by the presentation of a reversal of motion such that movement is along the tail-end of the animal's major axis. Ward documented phototaxive reversal being facilitated at higher intensities, shorter wavelength of light, and by light flashes lasting around one second.

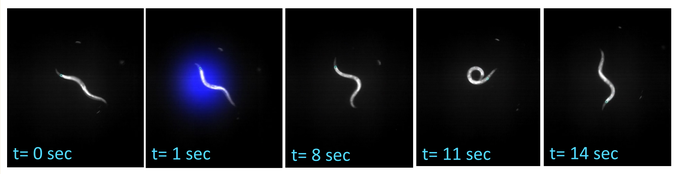
WORM TRACKING WITH PHOTO STIMULATION

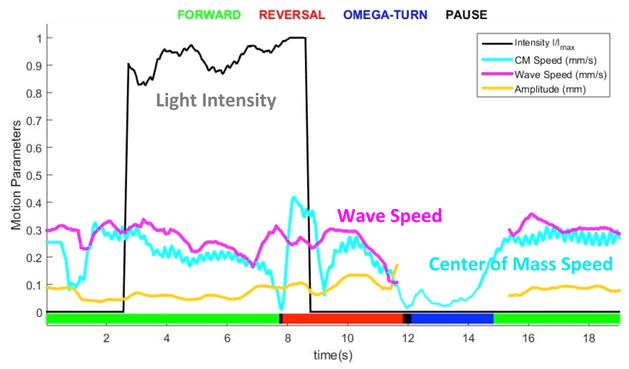


Layout of light stimulation and observation machinery situated in Knudsen A-166. Our setup allows for automated tracking of specimens using a stationary camera and stimulation apparatus coupled to a motorized stage. UV, IR, and blue light stimulation can be applied at varying intensities and durations.

RESULTS OF PHOTOSTIMULATION

Response in 2% Gelatin





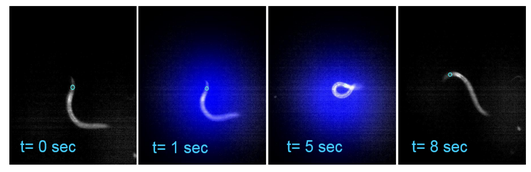
Top Left: Classical response: reversal of motion followed by an omega turn, is predominant in 2% gelatin.

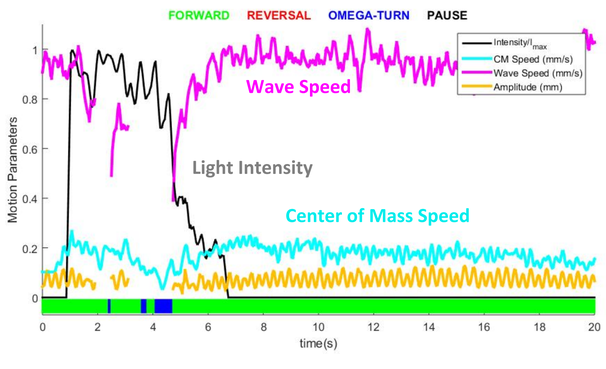
Top Right: In 1% gelatin, the majority of responses present with only omega turns without a preceding reversal.

Bottom Left: MATLAB-generated algorithmic quantification of light stimulation response in 2% gelatin showing a classical response (top left).

Bottom Right: Quantification of response in 1% gelatin depicting the reversal-deficient response common in this medium (note right). Note the increased wave speed (pink) as compared to 2% response (bottom left).

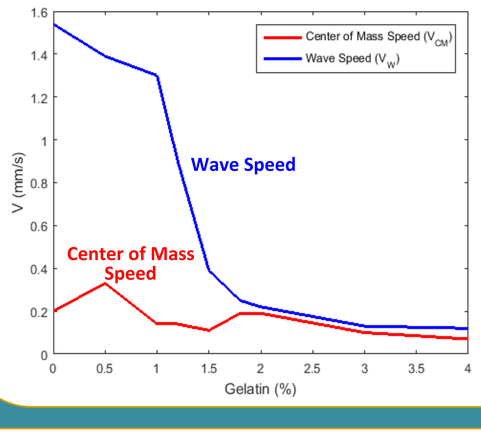
Response in 1% Gelatin



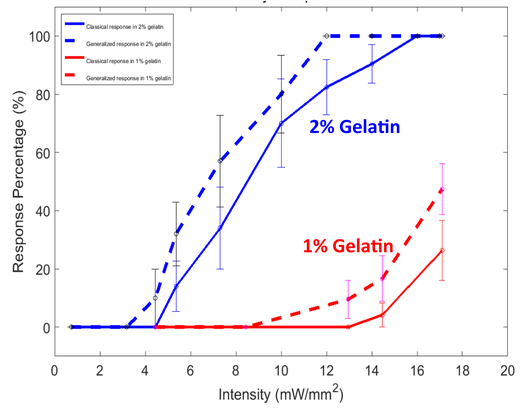


RESULTS: AVOIDANCE IS SUPPRESED AT HIGH WAVE SPEEDS

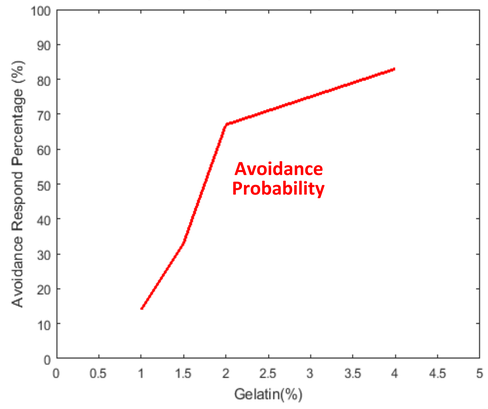
Two Types of Speed vs. Gelatin Concentration



Avoidance Probability vs. Light Intensity



Avoidance Probability vs. Gelatin Concentration



CONCLUSION

- Frequency of wave motion increases in lower concentrations of gelatin, with a dramatic shift occuring between 2% and 1%, whereas center of motion speed remains roughly constant.
- As predicted by previous studies[3], higher intensity blue light stimulation results in a higher rate of avoidance response.
- Overall responsivness decreases in low concentrations of gelatin, with the most notable shift in responsivenss occuring from 2% to 1% gelatin, concurrent with increases in wave speed.
- These findings are consistent for both "full" avoidance behavior and generalized avoidance behavior.
- Taken together, these findings imply **a rudimentary level of motion awareness through which this simplistic organism is capable of regulating its motion.**

REFERENCES

1. Kandel, E. (2000). The neurobiology of behavior. In: E. Kandel, J. Schwartz, T Jessell (Eds.), Principles of Neural Science (pp. 5-66). New York: McGraw-Hill Medical.
2. Crapse TB, Sommer MA. Corollary discharge across the animal kingdom. Nature Reviews. Neuroscience. 2008;9:587–600
3. White, J.G., Southgate, E., Thomson, J.N., and Brenner, S. (1986). The structure of the nervous system of the nematode Caenorhabditis elegans. *Philos. Trans. R. Soc. Lond., B, Biol. Sci.* 314:1-340.
4. Rankin CH. (2002) From gene to identified neuron to behaviour in Caenorhabditis elegans. *Nat Rev Genet.*2002. 3:622–630.
5. Ward, A., Liu, J., Feng, Z.,and Shawn Xu, X. Z. (2008). Light-sensitive neurons and channels mediate phototaxis in *C. elegans*. *Nat Neurosci.*, 11(8), 916–922.

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