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Vibration Response: Mapping the Behavioral Response of Fruit Fly Larvae to Mechanical Stimuli

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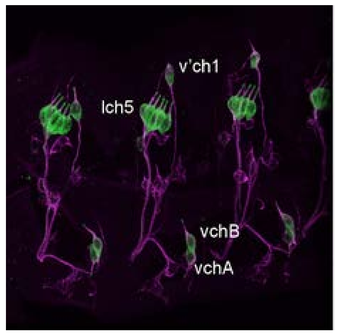
In what ways does Mechanosensory information generate a measurable response?

Touch response, as well as reaction to vibration, shaking, or sound, are behaviors shared by most organisms, though, the underlying mechanisms which characterize a creature's behaviour as a function of such stimuli is not well understood. Fruit fly larvae, due to their palette of simple behaviors, are a useful model system and can be used to map the mechanical response. Vibration is an easily paramaterized and reproducable mechanical stimulus which varies according to only frequency and acceleration. This study hypothesized that:

1. The strength of response in *Drosophila* larvae increases with frequency
2. Strength of response increases with accelleration.
3. The two variables in conjunction create an additive response

Study Significance

Understanding the function of Cordotonal Neurons and Cordotonal Complexes.

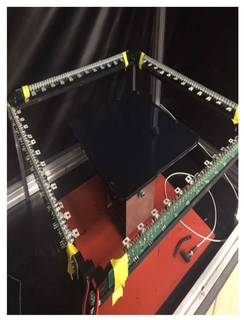


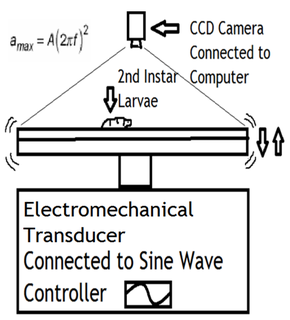
Past studies have shown that the *Drosophila*'s ability to detect a mechanical stimulus (i.e. auditory, procioception,, touch sensitivity, and locomotion feedback) stems from four Distinct Chordotonal neural complexes which have been identified: Ch1, lch5, vchA, and vchB, but the nature of how either complex functions is currently unknown.
This study identifies variables which suggest that these chordotonal complexes play distinct but related roles, and allow for future tests (with mutants) to classify each neuron's final effect on response.

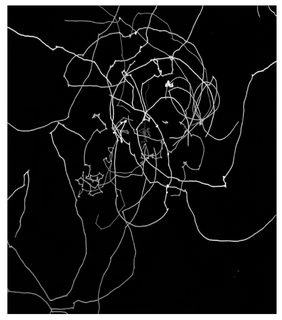
Methods

Second-instar wild-type fruit fly larvae are placed in a light and temperature controlled environment, and observed crawling on vibrating agar plates with a CCD camera. Larvae are monitored for their instantaneous speed, turn rate, stop rate, head swings, and change of direction; and such behavioral metrics are then analyzed and compared with those of other experiments under different stimulus conditions in MATLAB

Sets of Larvae were observed for 600 seconds, and vibrated every 30 seconds for a duration of 10 seconds, starting at second 90. 5 trials using vibrations with accelerations at 0.5g , 1g, and 2g each were conducted



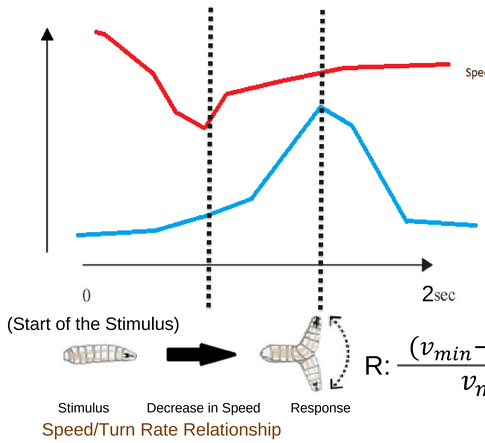




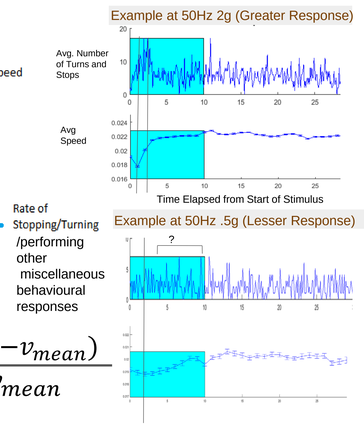
Laboratory Setup/ Paths of Larvae Tracked by Camera

at three different frequencies: 50Hz, 200Hz, and 500Hz. Control trials which lack a vibrational stimulus were also carried out for comparison. Vibrational amplitude and frequency were controlled with a power-amplifier, a manual sinewave controller, and a test electromechanical transducer.

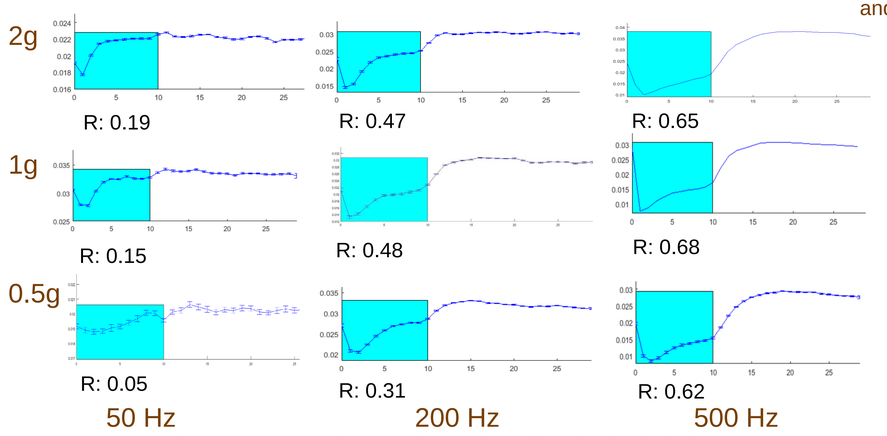
Results



Speed/Turn Rate Relationship



A change in speed can be used to indirectly measure the magnitude of response using a simple metric: the R Value. The R value is determined by the average difference between a larva's minimum and mean speeds, divided by mean speed.



Average Speeds over 30-second Intervals Starting with Stimulus (Blue)

The R value for the control experiment was R= 0.0164

Accel.	50 Hz	200 Hz	500 Hz
2g	0.19	0.47	0.65
1g	0.15	0.48	0.68
.5 g	0.05	0.31	0.62

R Values vs. Stimulus

Conclusion

What can be concluded:

- Acceleration correlates positively, and with response
- Increasing frequency correlates positively with response
- The two are additive, up to a certain point

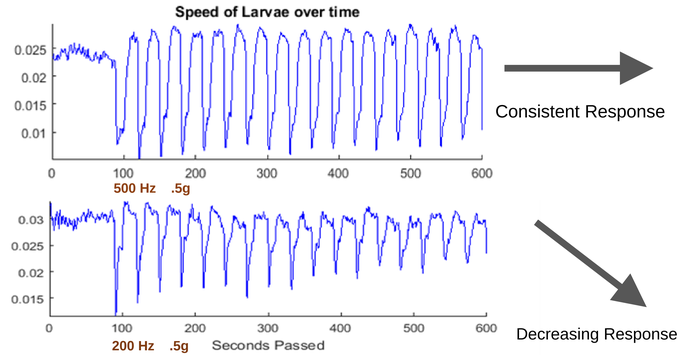
What can be conjectured:

- Both stimuli's effect on final response is positively correlated with the magnitude of the stimulus, but only to a certain cutoff saturation point for acceleration that is known.
- The ability to sense either acceleration or frequency likely operates via distinct neuronal mechanisms; though, when the mechanism for frequency is sufficiently triggered, it mediates the response to acceleration, thus indicating that the two mechanisms should crossover and affect eachother.
- Both mechanisms are likely non-binary: they tend to operate as a function of external stimulus, rather than simply turning 'on' or 'off'.

Future Studies

Habituation

Experiments suggest a relationship between long-term behavioral changes and stimulus type.



Independent Mechanisms

Neurological studies, which specifically try to identify and classify the activation mechanism which is triggered by either stimulus variable, can be performed.
The two mechanisms can themselves be mapped, to identify where crossovers (in the Chordotonal complex) likely occur.