Responses to mechanically and visually cued water waves in the nervous system of the medicinal leech

Supplemental material

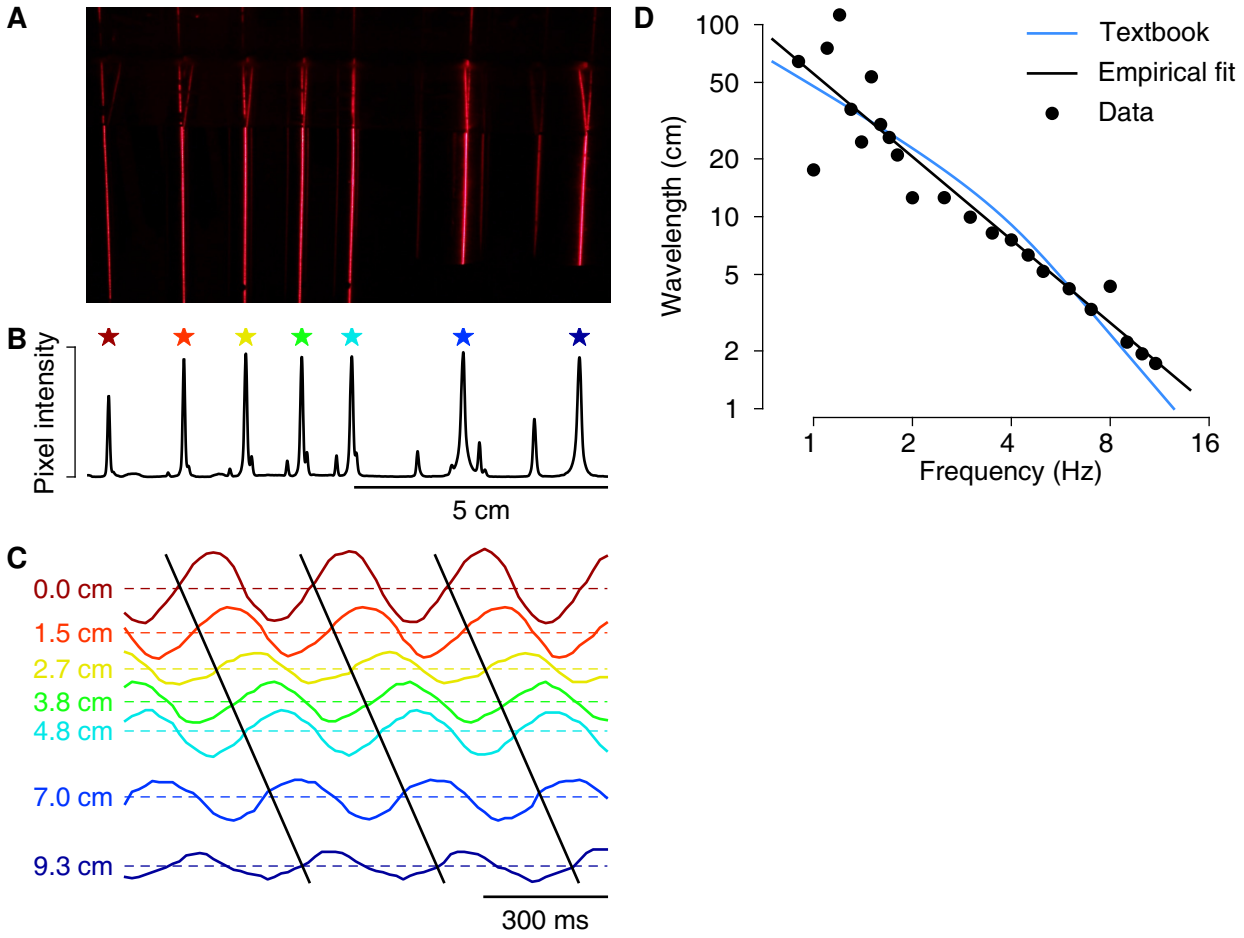

Figure S1. Determining the dispersion relation of physical waves. **A.** Photograph of the reflections of several shiny bars placed behind the aquarium. The bottom part of the reflection was used for measurements; the top part is a secondary reflection in the back wall of the aquarium. The bars are spaced irregularly to avoid aliasing of the measurements. **B.** Intensity profile across the image with peaks marked. **C.** Displacement of the reflections as a function of time during a 3-Hz wave. Colored traces correspond to points marked in (B). Vertical distance between traces is proportional to actual distance between bars. Displacement is exaggerated 50x. Black lines demonstrate linear propagation of the wave fronts.

D. Results. Data points are based on fitting a sine function

$$\Delta x(t) = A \sin\left(2\pi f t - \phi_x\right)$$

to the undulations of the reflections of a shiny metal bar placed behind the aquarium. In the equation, Δx is the observed displacement, f is the known frequency of the wave, t is time, x is the distance between the bar and the wave generator, A is an amplitude to be fitted, and ϕ_x is a phase shift to be fitted. After determining ϕ_x for a number of locations, we can calculate the wavelength λ of the wave by least-square fitting of $\phi_x = \phi_0 + x/\lambda$. Repeating this exercise for various frequencies f yielded the *black points*. The *black curve* is the best power law fit fit through the data:

$$1/\lambda = A f^B.$$

Least-square fitting of all our data (27 recordings at different frequencies) resulted in:

$$A = 0.0198 \pm 0.0014 \qquad \text{and} \qquad B = 1.414 \pm 0.033,$$

when frequencies were measured in hertz and wavelengths in centimeters. The *blue curve* is the textbook equation:

$$f = \sqrt{\left(g/2\pi\lambda\right) \tanh\left(2\pi h/\lambda\right)},$$

where h is the depth of the water (2.4 cm) and g is the gravity acceleration (9.81 m/s^2). Note the logarithmic axes. Data at low frequencies are more scattered because of deviations from pure sinusoidal waves at the larger-than-typical wave amplitudes used for these experiments.

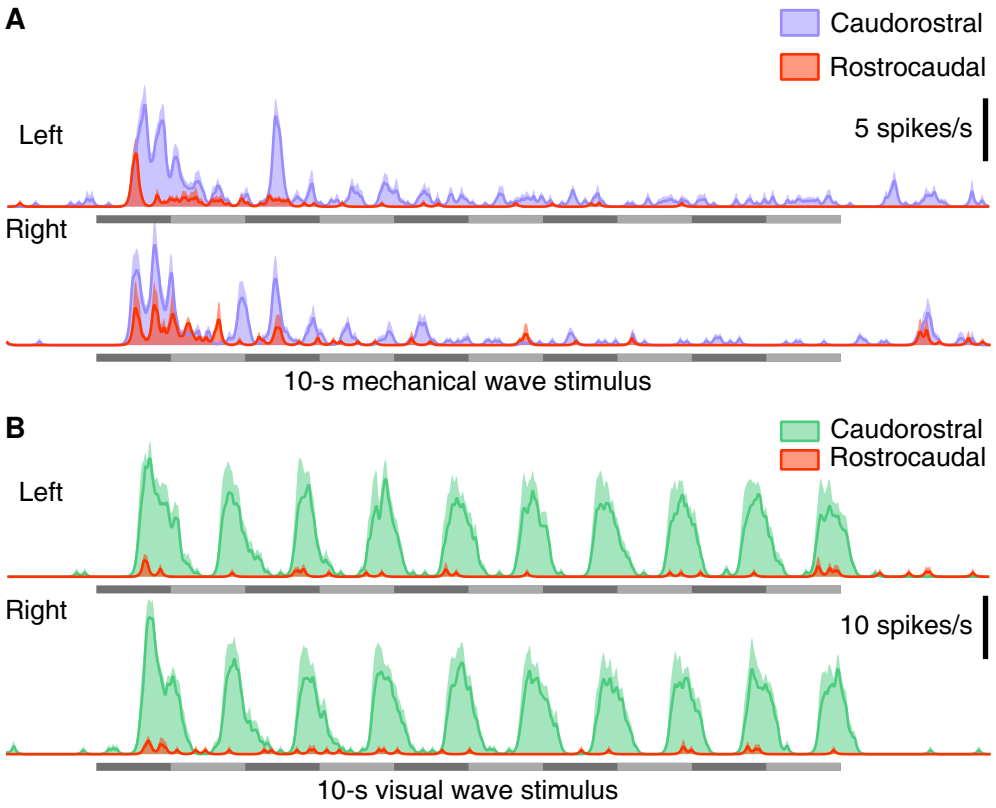

Figure S2. Dependence of S-cell responses on wave direction. **A.** Rate of caudorostrally (tail-to-head; purple) and rostrocaudally (head-to-tail) propagating spikes in response to 1-Hz mechanical waves approaching the animal from the left (top) or right (bottom). **B.** Same for visual waves. Compare to Figure 3D, E.