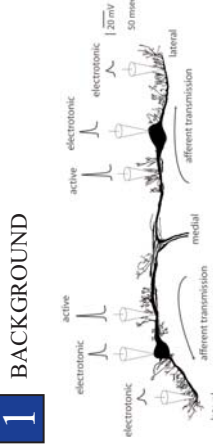


Regulation of spike propagation in a sensory neuron with an inexcitable somatic region:

Somatic depolarization promotes conduction without disrupting the peripheral encoding of afferent information

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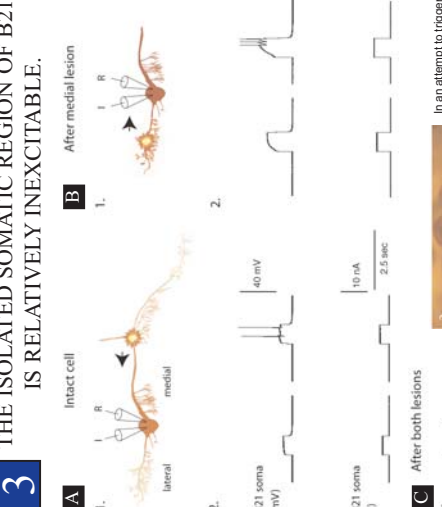
1 BACKGROUND



We study an Aplysia sensory neuron, a bipolar mechanoreceptive B21. When B21 is peripherally activated at its resting membrane potential, a spike propagated by current injection, the lateral process, is not transmitted to follower neurons contacted by an output region, the lateral process. When B21 is centrally depolarized, the propagation failure is relieved, and afferent transmission is restored. The goal of the present study was to determine why spikes fail to propagate when B21 is peripherally activated at its resting membrane potential. More specifically, we initially sought to determine whether there are regional differences in excitability in B21.

In a previous study we demonstrated that spikes can be triggered in the isolated lateral process (Evans et al., 2003).

3 THE ISOLATED SOMATIC REGION OF B21 IS RELATIVELY INEXCITABLE.



A Intact cell. **B** After medial lesion. **C** After both lesions.

1. Intact cell. 2. After medial lesion. 3. After both lesions.

Electron micrographs show the intact cell (A), the cell after medial lesion (B), and the cell after both lesions (C). The traces show membrane potential (mV) and current (nA) responses to current injection. Scale bars: 40 mV, 10 nA, 2.5 sec.

Fig. 3B1, i.e., the medial process was severed. SEVC experiments were then conducted in normal saline at a holding potential of 0 mV. A single step depolarization of 200 ms and were given every 70 s. Note that net currents are outward.

2 SPIKES CAN BE TRIGGERED IN THE ISOLATED MEDIAL PROCESS



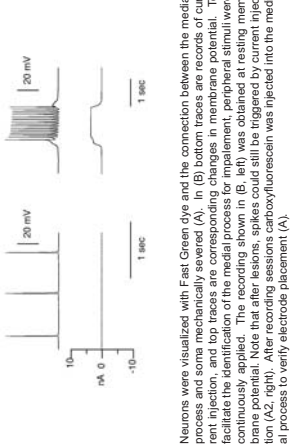
A Fluorescence micrograph showing a lesion in the medial process of a B21 neuron. **B** Traces showing peripheral stimulation and current injection. Scale bars: 10 nA, 20 mV, 1 sec.

4 NET CURRENTS EVOKED BY DEPOLARIZING STEPS ARE OUTWARD IN THE ISOLATED SOMATIC REGION OF B21



Traces showing net currents evoked by depolarizing steps in the isolated somatic region of B21. Scale bars: 10 nA, 20 mV, 100 msec.

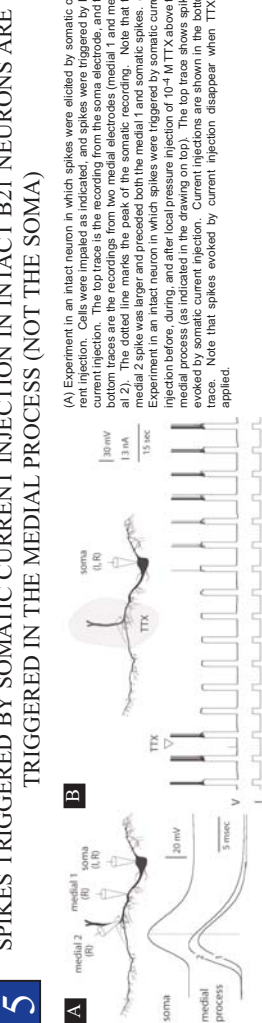
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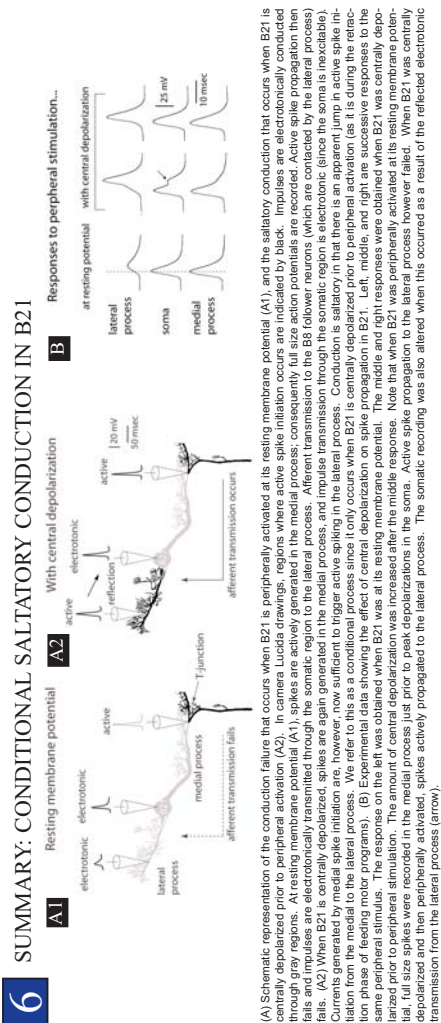
B21 neurons were mechanically severed as shown in Fig. 3B1, i.e., the medial process was severed. SEVC experiments were then conducted in normal saline at a holding potential of 0 mV. A single step depolarization of 200 ms and were given every 70 s. Note that net currents are outward.

5 SPIKES TRIGGERED BY SOMATIC CURRENT INJECTION IN INTACT B21 NEURONS ARE TRIGGERED IN THE MEDIAL PROCESS (NOT THE SOMA)



A Micrographs showing intact B21 neurons with medial (M) and lateral (L) processes. **B** Membrane potential traces showing responses to current injection in the medial process (M) and lateral process (L). Scale bars: 20 mV, 5 msec.

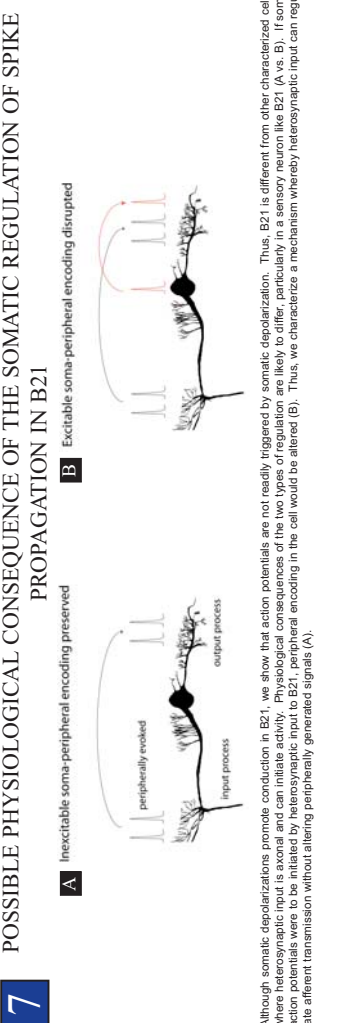
6 SUMMARY: CONDITIONAL SALTATORY CONDUCTION IN B21



A1 Resting membrane potential. **A2** With central depolarization. **B** Responses to peripheral stimulation.

Schematic (A) shows the neuron with resting membrane potential (A1) and with central depolarization (A2). Traces (B) show responses to peripheral stimulation at the resting potential and with central depolarization. Scale bars: 20 mV, 5 msec.

7 POSSIBLE PHYSIOLOGICAL CONSEQUENCE OF THE SOMATIC REGULATION OF SPIKE PROPAGATION IN B21



A Inexcitable soma-peripheral encoding preserved. **B** Excitable soma-peripheral encoding disrupted.

Schematic (A) shows a neuron with an inexcitable soma and preserved peripheral encoding. Schematic (B) shows a neuron with an excitable soma and disrupted peripheral encoding. Traces show membrane potential responses to input and output processes. Scale bars: 20 mV, 5 msec.

(A) Experiment in an intact neuron in which spikes were elicited by somatic current injection. Cells were impaled as indicated, and spikes were triggered by current injection. The top trace is the recording from the soma electrode, and the bottom traces are the recordings from two medial electrodes (medial 1 and medial 2). The dotted line marks the peak of the somatic recording. Note that the spikes in the medial process are triggered by somatic current injection.

Experiment in an intact neuron in which spikes were triggered by somatic current injection before, during, and after local pressure injection of 10⁻⁴ M TTX above the medial process (as indicated in the drawing on top). The top trace shows spikes evoked by somatic current injection. Current injections are shown in the bottom trace. Note that spikes evoked by current injection disappear when TTX is applied.

(A) Schematic representation of the conduction failure that occurs when B21 is peripherally activated at its resting membrane potential (A1), and the saltatory conduction that occurs when B21 is centrally depolarized prior to peripheral activation (A2). In camera Lucida drawings, regions where active spike initiation occurs are indicated by black. Impulses are electrotonically conducted through gray regions. At resting membrane potential (A1), spikes are actively generated in the medial process; consequently full size action potentials are recorded. Active spike propagation then fails to reach the lateral process through the somatic region. When B21 is centrally depolarized, spikes propagate through the medial process, electrotonically (since the soma is excitable) to the lateral process. Currents generated by medial spike initiation are, however, now sufficient to trigger active spiking in the lateral process. Conduction is saltatory in that there is an apparent jump in active spike initiation from the medial to the lateral process. We refer to this as a conditional process since it only occurs when B21 is centrally depolarized prior to peripheral activation (as it is during the retraction phase of feeding motor programs). (B) Experimental data showing the effect of central depolarization on spike propagation in B21. Left, middle, and right are successive responses to the same peripheral stimulus. The response on the left was obtained when B21 was at its resting membrane potential. The middle and right responses were obtained when B21 was centrally depolarized prior to peripheral stimulation. The amount of central depolarization was increased after the middle response. Note that when B21 was peripherally activated at its resting membrane potential, full size spikes were recorded in the medial process just prior to peak depolarizations in the soma. Active spike propagation to the lateral process however failed. When B21 was centrally depolarized and then peripherally activated, spikes actively propagated to the lateral process. The somatic recording was also altered when this occurred as a result of the reflector electrotonic transmission from the lateral process (arrow).

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where heterosynaptic input is axonal and can initiate activity. Physiological consequences of the two types of regulation are likely to differ, particularly in a sensory neuron like B21 (A vs. B). If soma action potentials were to be initiated by heterosynaptic input to B21, peripheral encoding in the cell would be altered (B). Thus, we characterize a mechanism whereby heterosynaptic input can regulate afferent transmission without altering peripherally generated signals (A).