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RESEARCH NEWS

I_D helps verify coincidence detection

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***JGP* study (Dapino and Curti. https://doi.org/10.1085/jgp.202513883) reveals that the D-type K^+ current regulates coincidence detection by shaping electrical transmission between pairs of MesV neurons.**

Antonella Dapino and Sebastían Curti.

In addition to the release of neurotransmitters across chemical synapses, neurons can transmit electrical signals directly to their neighbors via gap junctions. These electrical synapses play crucial roles in neural circuit function, from the synchronization of action potential firing by groups of neurons to the phenomenon of coincidence detection, in which a neural circuit only responds if it receives multiple inputs simultaneously (1). In this issue of *JGP*, Dapino and Curti report that, by modulating the amplitude and dynamics of transmission across electrical synapses, the D-type K^+ current (I_D) regulates both the gain and precision of coincidence detection by mesencephalic trigeminal (MesV) neurons (2).

MesV neurons are a unique type of primary sensory neuron whose cell bodies are located within the brainstem and help to control jaw movements. Pairs of MesV neurons are electrically coupled via connexin 36–containing gap junctions in their cell bodies (3). This electrical coupling enables coincidence detection. If only one MesV neuron is depolarized, some of the current leaks into its partner, reducing the probability of action potential firing. If both neurons are depolarized simultaneously, however, little to no current is transmitted across the electrical synapse, and the probability of action potential firing is enhanced.

Sebastián Curti, Antonella Dapino, and colleagues at Universidad de la República in Montevideo, Uruguay, previously found that the strength of MesV electrical coupling is regulated by I_D (4), an outward potassium current that shows rapid activation kinetics at subthreshold voltages and is thought to be mediated by Kv1 channels. I_D regulates coincidence detection in the auditory system, although, in this case, the detection is carried out by pairs of dendrites from a single neuron. "We set out to investigate whether I_D also contributes to shaping coincidence detection in networks of electrically coupled neurons," Curti says.

By pharmacologically inhibiting Kv1 channels in mouse brainstem slices, Dapino and Curti found that I_D shapes the intrinsic electrophysiological properties of MesV neurons, suppressing their overall excitability (2). Further analyses revealed that the I_D is highly expressed at the axon initial segment of MesV neurons. This axonal compartment is electrotonically coupled to the cell body, allowing I_D to influence the soma's electrophysiological properties and the dynamics of electrical synapse transmission.

"Because of its rapid activation, I_D acts as a dynamic brake on depolarizing events such as the spike-evoked coupling potentials (spikelets) that are transmitted through electrical synapses," Curti says. "By opposing these depolarizations, I_D reduces the overall strength of electrical coupling and, at the same time, shortens the duration of spikelets by speeding their decay."

This reduction in the amplitude and duration of signals transmitted across the electrical synapse has significant effects on coincidence detection. By performing paired recordings of electrically coupled neurons in the presence and absence of Kv1 inhibitors, Dapino and Curti found that I_D increases the temporal precision of coincidence detection, allowing pairs of MesV neurons to distinguish simultaneous inputs from inputs occurring just microseconds apart. This comes, however, at the cost of reducing the gain of coincidence detection: I_D reduces the difference in firing rate for simultaneous versus asynchronous inputs.

"Thus, while electrical coupling provides the substrate for coincidence detection, our results highlight how active electrophysiological properties—specifically I_D—critically tune the gain and temporal resolution

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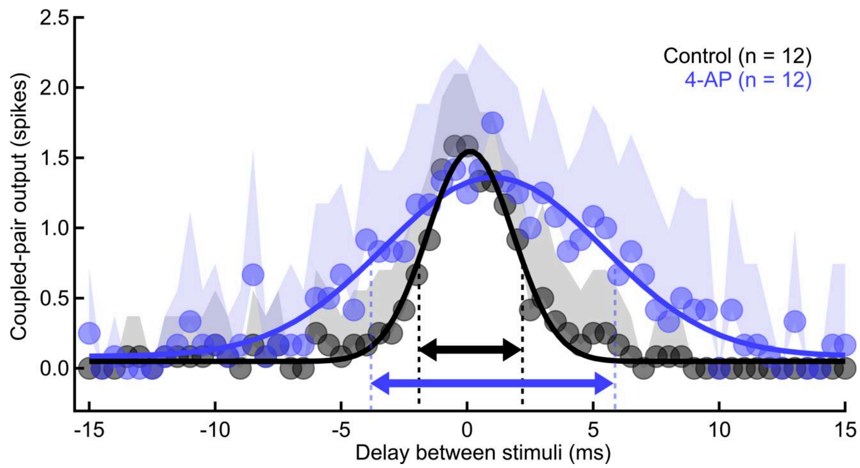

Dapino and Curti show that, by shaping the dynamics of electrical synaptic transmission, I_D modulates coincidence detection by electrically coupled pairs of MesV neurons. A plot of average spike counts shows that, compared with control neurons (black), the temporal precision of coincidence detection is reduced when I_D is inhibited by treatment with 4-aminopyridine (blue).

of this computation in coupled neuronal networks," Curti explains. "We now want to determine how changes in gap junction–mediated coupling or I_D dynamically reshape coincidence detection in electrically coupled circuits." The researchers are also interested in investigating how voltage-dependent conductances may influence other network operations mediated via electrical synapses.

References

1. Curti, S., et al. 2022. *Biology*. https://doi.org/10.3390/biology11010081
2. Dapino, A., and S. Curti. 2026. *J. Gen. Physiol.* https://doi.org/10.1085/jgp.202513883
3. Curti, S., et al. 2012. *J. Neurosci.* https://doi.org/10.1523/JNEUROSCI.6216-11.2012
4. Dapino, A., et al. 2023. *J. Gen. Physiol.* https://doi.org/10.1085/jgp.202313353