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Reprogramming the nociceptive circuit topology reshapes sexual behavior in C. elegans

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In sexually reproducing species, males and females respond to environmental sensory cues and transform the input into sexually dimorphic traits. Yet, how sexually dimorphic behavior is encoded in the nervous system is poorly understood. We characterize the sexually dimorphic nociceptive behavior in C. elegans – hermaphrodites present a lower pain threshold than males in response to aversive stimuli, and study the underlying neuronal circuits, which are composed of the same neurons that are wired differently. By imaging receptor expression, calcium responses and glutamate secretion, we show that sensory transduction is similar in the two sexes, and therefore explore how downstream network topology shapes dimorphic behavior. We generated a computational model that replicates the observed dimorphic behavior, and used this model to predict simple network rewirings that would switch the behavior between the sexes. We then showed experimentally, using genetic manipulations, artificial gap junctions, automated tracking and optogenetics, that these subtle changes to male connectivity result in hermaphrodite-like aversive behavior in-vivo, while hermaphrodite behavior was more robust to perturbations. Strikingly, when presented with aversive cues, rewired males were compromised in finding mating partners, suggesting that the network topology that enables efficient avoidance of noxious cues would have a reproductive "cost". To summarize, we present a deconstruction of a sex-shared neural circuit that affects sexual behavior, and how to reprogram it. More broadly, our results are an example of how common neuronal circuits changed their function during evolution by subtle topological rewirings to account for different environmental and sexual needs.

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