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Tuning transduction from hidden observables to optimize information harvesting

Biological and living organisms sense and process information from their surroundings, typically having access only to a subset of external observables for a limited amount of time. Here, we uncover how biological systems can exploit these accessible degrees of freedom to transduce information from the inaccessible ones with a limited energy budget. We find that optimal transduction strategies may boost information harvesting over the ideal case in which all degrees of freedom are known, even when only finite-time trajectories are observed, at the price of higher dissipation. Our results can be further extended to the case in which only kinetic quantities can be direcly estimated from the stochastic evolution of the accessible degrees of freedom. We apply our results to red blood cells, inferring the implemented transduction strategy from membrane flickering data and shedding light on the connection between mechanical stress and transduction efficiency. Our framework offers novel insights into the adaptive strategies of biological systems under nonequilibrium conditions.

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