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Non-normal dynamics and positive feedback between motion and sensation boosts run-and-tumble navigation.[1] JUNJIAJIA LONG, STEVEN W. ZUCKER, THIERRY EMONET, Yale University — The capability to navigate environmental gradients is of critical importance for survival. Countless organisms (microbes, human cells, worms, larvae, and insects) as well as human-made robots use a run-and-tumble strategy to do so. The classical drawback of this approach is that runs in the wrong direction are wasteful. We show analytically that organisms can overcome this fundamental limitation by exploiting the non-normal dynamics and intrinsic nonlinearities inherent to the positive feedback between motion and sensation. Most importantly, this nonlinear amplification is asymmetric, elongating runs in favorable directions and abbreviating others. The result is a "ratchet-like" gradient climbing behavior with drift speeds that can approach half the maximum run speed of the organism. By extending the theoretical study of run-and-tumble navigation into the non-mean-field, nonlinear, and non-normal domains, our results provide a new level of understanding about this basic strategy.

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Thierry Emonet
Yale University

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