**S1 Text**

**Observations from modeling of single-cell behavior**

The angular velocity *ψ* is related to the tangential velocity *v* and the radius *s* of the curvature of the cell trajectory as making this parameter proportional to the cell velocity and inversely proportional to the radius of curvature. We observed that the angular velocity initially increases with hook-length. This corresponds to a decrease in the curvature radius of the trajectories, similar as observed before for sperm cells or other types of bacteria swimming near surfaces [1-5]. The angular velocity *ψ* decreases for longer trajectories, however, as a consequence of decreased run speed *v*. We also note that we were unable to reproduce the experimental observables of the short-hook (FliK335) che− mutant by a single parameter couple (*ψ*,*λ*) in the context of our run-and-tumble model, which suggested that the movement of those mutants is not diffusive (S7 Fig). We suggest that the observed heterogeneous hook-length distribution of the FliK335 mutant (S3 Fig) explains the poor fit to a single parameter couple.

**S1 Text References**

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