Drift velocity of bacterial chemotactic response with two alternating turning events and arbitrary persistence parameters

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Bacterial chemotaxis has been extensively studied in the past decades [1-5]. One of the most interesting issues is the strategies used by bacteria to reach (or leave) the place with the maximal concentration of the chemical. Experimental observations revealed various types of random walk-like patterns produced by bacteria when drifting towards the source of the attractant. One of the best known example is the run-and-tumble strategy of *E. coli*. Reorientations of these bacteria during the tumble events exhibit persistence of the direction: the mean angle between the new and the previous directions is near 62° [1]. The chemotactic efficiency of the bacteria utilizing strategies with constant persistence (*E. coli*, *S. putrefaciens*, *P. haloplanktis*, to name a few) was theoretically studied by using the idea of de Gennes [2,3]. Recently, this approach was generalized to a strategy that is composed of two types of alternating tumbling events, namely, tumbles with some constant persistence ("tumbles") and random turns at the plane perpendicular to the direction of the current motion ("flicks") [4]. Since every flick erases the memory on the motional history, the analytical calculation of the net drift velocity is relatively simple in this case. Results obtained for the corresponding model show that the run-reverse-flick strategy (which is a good approximation, for instance, for the walk performed by *V. alginolyticus*) yields larger net velocity (and thus much more efficient) when compared to the *E. coli*-type run-and-tumble strategy. Recent experimental analysis of *V. alginolyticus* chemotactic motility showed that for these bacteria the flick angle depends on the size of the cell body and only after averaging over the ensemble of cells it results in $\sim 90°$ [5]. Thus there is a need to consider a strategy with two turning angles, both are different from 90°. Following de Gennes idea, we analytically calculate drift velocity for the strategy with two alternating tumbling angles. We demonstrate complete agreement of the obtained result with the specific cases considered in Refs. [3,4]. It is noteworthy that our model allows to take into account size inhomogeneity of cellular population (specified with the persistence parameter variation) thus allowing to relate a chemotactic pattern to the size structure of the cell population that produced it.

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