Intermittent search strategies.

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Search strategies are crucial in various domains, ranging from chemistry, biology, to rescue operations. In lot of cases, the target is difficult to detect. In some cases, there is the choice between two search phases, one of slow motion but enabling detection, and another phase of faster motion, but non-reactive. For example, the perception of animals searching for a hidden prey can be degraded by speed [1]. Another example is transport within biological cells, where reactants can either freely diffuse or bind to motors which perform ballistic motion on the cytoskeleton [2].
I will present a model taking into account this intermittency [3,4]: diffusive reactive phases alternate with ballistic non-reactive phases. We wonder whether "losing" time in the fast non-reactive phase makes reaction faster. And if so, we wonder if there is an optimal way to share time between the two phases. To answer these questions, we calculate explicitly mean first passage time on the target. We conclude that intermittency minimizes the mean first passage time on the target under some conditions, and that there are optimal durations of the two phases: there is an optimal strategy. We studied this model in one, two and three dimensions. All these cases are relevant for example to reactant transport within biological cells. Indeed, structures like dendrites can be considered as one-dimensional, membranes are two-dimensional, cytoplasmic bulk is three-dimensional. The dependence with the target density is important in the one-dimensional case, low in the two-dimensional case, but disappears in the three-dimensional case. Our results are robust, as the optimal duration to spend in the ballistic phase is quite independent from the description of the reactive phase.

[1] W.J. O'Brien et al., American Scientist **78**, 152 (1990).
[2] B. Alberts et al., *Molecular Biology of the Cell* (Garland, New York, 2002).
[3] O. Bénichou, C. Loverdo, M. Moreau and R. Voituriez *Two-dimensional intermittent search processes: An alternative to Lévy flight strategies*, Phys. Rev. E **74**, 020102 (2006); reviewed by M.F. Shlesinger, *Search research*, Nature **443**, 281 (2006).
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