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How noisy intercellular and intracellular signaling dynamics produce group-level decision-making --- a lesson from microbial chemical communication

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Abstract

Although the genetic circuits underlying state switching at the single-cell level are well understood, how such circuits work in concert among many cells with intrinsic heterogeneity to support the population-level switching of cellular behaviors is not fully explored. Experiments using microbial noisy signaling systems show that group-level changes in cellular state occur in either a graded or an all-or-none fashion. We show that the type of group-level decision making used by populations is uniquely determined by a single dimensionless parameter that compares the quorum-signaling molecules accumulated within the cells with those secreted by the population. Bacterial quorum-sensing circuits appear to be tuned so that the cells can convert between the two types of decision-making in response to slight variations of biochemical properties. Furthermore, the role of the parameter is universal such that it not only applies to the autoinducing circuits typically found in bacteria but also to the negative feedback circuit that produces collective temporal oscillations [1] from bacteria to mammalian cells. The design principle that we describe thus serves as the basis for the analysis and control of collective cellular decision making in general [2].

References

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[2] K. Fujimoto, S. Sawai, *Submitted*.