Abstract

Eggs attract sperm by releasing chemical factors (chemoattractant). In the sperm of sea urchin *Arbacia punctulata*, the signaling mechanisms underlying chemotaxis in response to stimulation by its chemoattractant peptide resact have been elucidated. Sperm are sensitive to a single molecule of resact and can encode resact concentrations varying over 6 orders of magnitude. But nothing is known about their recovery from stimulation and regulation of sensitivity during their journey along the chemoattractant gradient.

Here, I studied sensitivity regulation in sperm under different pre-stimulus conditions. I describe four characteristic features – sampling, interference/refraction, adaptation, and recovery/sensitization – that encompass the entire gamut of sensitivity regulation.

1. *Sampling:* Sampling describes the ability to register the stimuli for a certain period of time and then generate a cellular response. I show that sperm linearly sum up consecutive stimuli separated by ≤50 ms as shown by Ca^{2+} measurements. The sampling period is determined by the time required to open Ca_v channels.
2. *Interference/Refraction:* During the transient Ca^{2+} response, the cell continues to respond to stimulation with hyperpolarization to second stimulation, but $[Ca^{2+}]_i$ drops rapidly (sag) and recovers subsequently. Thus, the second stimulus interferes with the signal that was evoked by the first stimulus. The sag is produced by the closure of open Ca_v channels and by the enhanced activity of Na^+/Ca^{2+} exchanger.
3. *Adaptation*: During the course of a Ca^{2+} response and recovery, the cell lowers its sensitivity to additional stimulation, i.e. the cell adapts. Obeying Weber's law, the sensitivity is inversely related to the strength of the background stimulus.
4. *Recovery/Sensitization:* The adaptation disappears gradually and the response recovers when the interval between stimuli is sufficiently long. The sensitivity recovered more slowly and less completely for high background concentrations. In some cases, sensitivity was even enhanced, i.e. they sensitized. The extent of adaptation, recovery, and sensitization depends on the respective strengths of first and successive stimuli. The sensitization was

most pronounced for high background concentrations and stronger test stimuli. For example, for background and test concentrations of 5 nM and 2.5 nM, respectively, the Ca^{2+} response was enhanced by 3-fold.

These unique features endow sperm to produce periodic Ca^{2+} signals and to maintain high sensitivity in a continuous gradient or even in a patchy distribution of chemoattractant that spans orders of magnitude.