Phospholipase C-mediated suppression of dark noise enables single-photon detection in Drosophila photoreceptors.

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Abstract:

Drosophila photoreceptor cells use the ubiquitous G-protein-mediated phospholipase C (PLC) cascade to achieve ultimate single-photon sensitivity. This is manifested in the single-photon responses (quantum bumps). In photoreceptor cells, dark activation of G(q)? molecules occurs spontaneously and produces unitary dark events (dark bumps). A high rate of spontaneous G(q)? activation and dark bump production potentially hampers single-photon detection. We found that in wild-type flies the in vivo rate of spontaneous G(q)? activation is very high. Nevertheless, this high rate is not manifested in a substantially high rate of dark bumps. Therefore, it is unclear how phototransduction suppresses dark bump production arising from spontaneous G(q)? activation, while still maintaining high-fidelity representation of single photons. In this study we show that reduced PLC catalytic activity selectively suppressed production of dark bumps but not light-induced bumps. Manipulations of PLC activity using PLC mutant flies and Ca(2+) modulations revealed that a critical level of PLC activity is required to induce bump production. The required minimal level of PLC activity selectively suppressed random production of single G(q)?-activated dark bumps despite a high rate of spontaneous G(q)? activation. This minimal PLC activity level is reliably obtained by photon-induced synchronized activation of several neighboring G(q)? molecules activating several PLC molecules, but not by random activation of single G(q)? molecules. We thus demonstrate how a G-protein-mediated transduction system, with PLC as its target, selectively suppresses its intrinsic noise while preserving reliable signaling.

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