Zebrafish Larva's Response and Habituation to Electric Signal: Effects of Voltage, Current and Pulsation Studied in a Microfluidic Device

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Abstract

We previously showed that electric current can cause zebrafish larvae to move towards the anode pole along a microchannel. For a semi-mobile larva, we observed that zebrafish response to electricity depended on the current magnitude. The effects of electric signal direction, voltage magnitude and habituation to repeated exposures to electric pulses were not characterized. Here, this knowledge gap was addressed by exploiting these parameters in a microfluidic device with a head-trap to immobilize a zebrafish larva and a downstream chamber for tail movement and phenotypic characterization of response duration (RD) and tail beat frequency (TBF). We first assessed larvae's response to electric current direction (at 3μA) and voltage magnitude. Changing the current direction significantly altered the RD and TBF with long and low-frequency responses seen when the anode was positioned at larvae's tail. The electric voltage drop across the fish body had a significant effect on larvae's locomotion with long RD and low TBF observed at 5.6V in the range of 1.3-9V. We also demonstrated that the zebrafish locomotor response to repeated 3μA current pulses diminished with dependency on the interstimulus interval. However, the diminished response was fully recovered after a 5-min resting period or introduction of a novel light stimulus (i.e. habituation-dishabituation strategy). Therefore, electric response suppression in zebrafish was attributed to the habituation as a form of non-associative learning. Our microfluidic platform has broad application potential in behavioral neuroscience to study cognitive phenotypes, fundamental studies on the biological roots of electric response, and pharmacological screening.

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