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Chemosensory Modulation of Eye-body Coordination in Larval Zebrafish

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Coordinated eye-body movements underlie a wide range of visuomotor behaviors essential for diverse animal activities, yet whether and how they are modulated by cross-modality sensory input remains elusive. Here, by advancing the behavioral and neuronal activity imaging platform Fish-On-Chips, we reveal that zebrafish larvae employ coupled saccade-tail flips for chemosensory avoidance but not pursuit. Spontaneous saccade-turn events are preceded by tail flips which gradually decrease in rate, reverse in directional bias, and increase in magnitude. In response to aversive chemicals, but not appetitive ones, larval zebrafish amplifies saccade-tail flip coordination. This is manifested by subtle generation of more saccades and significantly stronger correlation between tail flip magnitude and synchrony with saccade, compared to appetitive or null chemical stimulation. Following saccade-turn events, an elevated magnitude is sustained over multiple tail flips. On a brain-wide scale, neuronal ensembles that track anticipatory tail flip parameter changes for saccade-turn coordination are largely overlapping with those preferentially activated by aversive chemicals over appetitive ones. Our findings suggest that a cross-modal interplay of chemosensation, saccades, and locomotion emerged in a vertebrate species at least 450 million years ago.