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Filter Neurons for Specific Optic Flow Patterns in the Fly's Visual System.

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The control of locomotion in a given environment requires information about instantaneous self-motion. Visually oriented animals, including man, may gain such information by analyzing the momentary optic flow pattern generated over both eyes during relative movement between animal and environment. Optic flow patterns can be described by vector fields where each single vector indicates the direction and velocity of the local relative movement at a certain position within the visual field. An optic flow pattern depends upon a set of motion parameters, namely (i) the direction of gaze and (ii) the rotatory and (iii) translatory components of self-motion. The translatory flow vectors also depend an the distance between visual objects and the eyes. Therefore, optic flow fields contain valuable information about the 3D-layout of the surroundings and instantaneous self-motion (Koenderink and van Doorn, 1987).

About 50 motion-sensitive, wide-field interneurons which are assumed to be' involved in locomotor control are located in the third visual neuropil (lobula plate) of the blowfly's *(Calliphora erythrocephala)* visual system (Hausen, 1993). The output of many direction-specific movement detectors (EMDS) with small receptive fields are spatially integrated in a retinotopic manner an the dendrites of these interneurons.

Are such interneurons adapted to sense specific aspects of the momentary optic flow field? To address this question, we investigated the receptive field organization of 10 identifiable interneurons of the so called vertical-system (VS; Hengstenberg, 1982) in great detail. We recorded intracellularly from the VS-neurons to determine the spatial distribution of local preferred directions and motion sensitivities at 52 positions spaced equally over the ipsilateral visual hemisphere (for method see: Menzel and Hengstenberg, 1991; Krapp and Hengstenberg 1992). The resulting response fields of the VS-neurons (about 90 recordings) show striking similarities to optic flow fields generated by specific motions in space (Krapp and Hengstenberg, 1994).

By applying an iterative least square formalism (Koenderink and van Doorn, 1987) to the response fields we calculated the optimal self-motion parameters (translatory and rotatory component) for each VS-neuron. These parameters describe an optic flow field that best fits the respective measured response field. To find out whether the VS-neurons are functionally tuned more to the translatory or to the rotatory component of self-motion we systematically varied the optimal motion parameters. The error between the measured response field and the calculated optic flow field increases if both the translatory and the rotatory component deviate from the optimal motion parameters. The increase in the error is almost the same if only the rotatory component is varied. In contrast, if the translatory component is varied and the rotatory component is kept optimal the increase in the error is considerably smaller.

The analysis of the response fields of the VS-neurons leads to the following conclusion: the VS-neurons are functionally tuned to sense rotations around different horizontally aligned body axes. The neurons VS1-VS3 are optimized to sense optic flow fields generated during nose-up pitch. VS4-VS7 are filter neurons for counterclockwise roll and VS8-VS10 are adapted to rotations around an axis that lies between the pitch and roll axes. Thus, the signals of the VS-neurons could contribute directly to visual flight control and gaze stabilization.