REPRESENTATION OF SPECIFIC OPTICAL FLOW FIELDS IN
LOBULA PLATE NEURONS OF THE BLOWFLY *Calliphora*

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An insect moving through optically structured surroundings generates on its eyes a sequence of optical flow patterns. Their structure depends upon the animal's instantaneous motion and on the three-dimensional layout of the surroundings. The flow pattern is analyzed by retinotopic arrays of small sets of elementary motion detectors (EMDs). Each set contains detectors that share a tiny portion of the visual field, but differ in their preferred directions. Local motion signals are, however, ambiguous in several respects, and may be caused by different motions in space. An unambiguous representation of self-motion requires that the appropriate local motion signals are selected from specific parts of the visual field, and are spatially integrated over the visual unit sphere. Such signals can be used by the fly to control its locomotion in space specifically.

In flies, visual motion is processed in different ways in the third visual neuropil (lobula plate; Hausen, 1984). Horizontal and vertical motion are represented in a stack of four retinotopic neuropil layers (Buchner & Buchner, 1982). Motion sensitive wide-field neurons (tangential neurons) arborize in delineated retinotopic areas, and in distinct neuropil depths (Hengstenberg et al, 1982). Receptive fields and directional preferences of some tangential cells seem to correspond with the location of their dendrites in the neuropil (loc cit). For most neurons, however, the functional structure of the receptive field is barely known. We have, therefore, developed a quick and reliable method to map within 20 min the local motion sensitivity and preferred direction of a neuron at 52 positions distributed reasonably over more than the ipsilateral visual hemisphere (Fig 1; Krapp & Hengstenberg, 1992). The resulting motion responses are represented as arrows in an azimuthal projection, balanced between equal area and equal angle (Fig 1). The arrow originates at the site of stimulation (d=dorsal, v--ventral, f=frontal, c=caudal); its orientation gives the preferred direction relative to the local coordinates, and its length denotes the motion sensitivity relative to the maximal response.

The measured motion response patterns are surprisingly clear "neural cartoons" of rotatory optical flow patterns: the "horizontal" neuron H1 is maximally stimulated by rotations of the fly about the vertical axis d-v (Fig l a). The "vertical" neuron V 1 is maximally stimulated by rotations about an oblique horizontal axis with an azimuth yf=120° (Fig lb). Note that both neurons show a stripe of high motion sensitivity along the rotation "equator", and low motion sensitivity near the poles of the rotation axis. These characteristics correspond very well with published receptive field properties of the H1- and V1-neuron (Hausen, 1976). Other extracellular recordings revealed that the lobula plate contains also neurons with more complex receptive field organizations. Their identification requires intracellular staining which usually shortens the recording time. We think, however, that our procedure is fast enough to allow both, a detailed analysis of the receptive fields by intracellular recording, and cell identification by dye injection.