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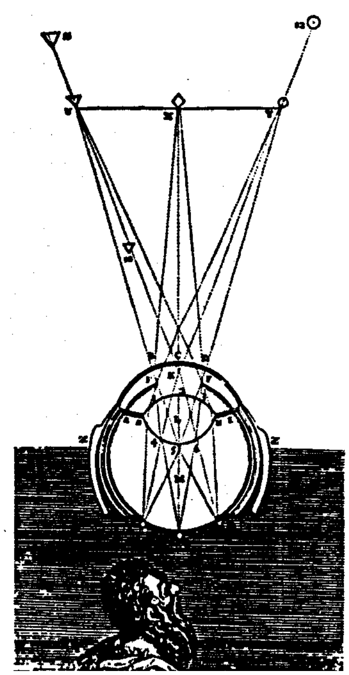

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FLICHT CONTROL CIRCUITS IN THE NERVOUS SYSTEM OF THE FLY: CONVERGENCE OF VISUAL AND MECHANOSENSORY PATHWAYS ONTO MOTONEURONS OF STEERING MUSCLES

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Flies are able to navigate in complex environments and to maintain their course even in presence of turbulente and motor asymmetries. This is achieved by a neural flight control system, which translates sensory informations about the self-motion of the animal and the structure of the surroundings into coordinated activity of steering muscles. lt has been demonstrated that the spike-activity in these muscles is modulated by visual and mechano-sensory inputs (motion and air currents), and that it is phase-coupled to the wingbeat cycle by proprioreceptive feedback from wings and halteres (Heide G in: Nachtigall W (Ed) Biona-Report 2, Fischer Verlag Stuttgart 1983, pp 35-52).

In the present study the neural circuitry mediating flight control was investigated light microscopically in the blowfly *Calliphora*. Motoneurons of steering muscles (direct flight muscles) and sensory pathways projecting from the optic lobes, antennae, wings and halteres into the thoracic ganglion were cobalt-labelled and analyzed with regard to their structural organization. Potential contacts between afferences and motoneurons were studied by simultaneous double impregnations. In addition, cobalt-infusions of long duration were employed to produce selectively higher order stainings of neurons. Such stainings are assumed to be due to cobalt-migration through gap-junctions and can, thus, demonstrate functional connections in the nervous system.

The Motoneurons (Mn) of the direct flight muscles b1, b2, I1, III1, ps1, ps2 were identified and reconstructed from horizontal serial sections. All show lange dendritic arborizations in the dorsal mesothoracic ganglion and additional dendrites in more ventral layers of the neuropil.

The dendritic main trunks of Mnb1, Mnb2 and MnIII 1 are cobaltcoupled to giant interneurons, which are part of a prominent commissure in the dorsal mesothoracic ganglion.

The axons of Mnbl, Mnb2, and MnIII1 project through the anterior dorsal mesothoracic nerve, those of MnIII1, Mnpsl and Mnps2 through the mesothoracic accessory nerve to their target muscles.

The visual pathway investigated originates in the motion processing centre of the optic lobe, the lobula plate. Motion sensitive output neurons of this neuropil terminate in visual areas of the ipsi- and contralateral deutocerebrum.

Cobalt-injections into these areas- resulted in staining of numerous descending elements projecting directly into the dendritic domains of the flight motoneurons.

Selective impregnations of the campaniform sensilla in the antennae, which monitor antennal deflections caused by air currents during flight, revealed five terminal areas of these receptors in the thoracic ganglion (see also: Nässel DR et al. (1984) 3 Morphol 180: 159). One of these lies in the dendritic domains of the flight motoneurons.

The mechanosensory projections of each haltere form a dense tract in the ipsilateral thoracic ganglion. Prolonged cobalt-infusions into halteres resulted in higher order stainings of the giant interneurons of the dorsal mesothoracic ganglion, and of the Mnb1, Mnb2, and MnIIIl (see Hengstenberg et al., this volume).

Stainings of the wing-nerve revealed a complicated pattern of projections in all three thoracic ganglia. Dense appositions between wing-nerve terminals and ventral dendrites of Mnbl and Mnb2 were found in the mesothoracic ganglion.

The results indicate strongly that the motoneurons (i) are synaptically connected to the giant interneurons of the dorsal mesothoracic commissure, (ii) receive direct mechanosensory input from the antennae, halteres and wings, and (iii) are linked via descending neurons to the motion processing centre of the visual system. This suggests that the modulation and coordination of their activity is achieved by multimodal integration of sensory inputs in their dendritic domains.