Introduction

The anterior optic tubercle (AOTu) is a small bilobed neuropil in the frontal lateral protocerebrum of the insect brain. In the desert locust it is located between the antennal lobe and the calyx of the mushroom body about 200 µm lateral of the α-lobe, underneath the frontal cell cortex. Although the AOTu has been found in all insect species investigated so far, little is known about the physiology of its neurons and its functional role. A few recordings from neurons with processes in the AOTu reported from several species (Sphinx ligustri, Apis mellifera, Sarcophaga bullata) showed responses to visual stimuli, in particular to movement stimuli.

Materials and Methods

Intracellular recordings with glass microelectrodes (tip filled with 4% Neurobiotin in 1 M KCl, backed up with 1 M KCl) were obtained from adult locusts of both sexes. The locusts were positioned in the center of a perimeter (Fig. 2). A light guide attached to the perimeter allowed to illuminate the locust head from left, dorsal and right as well as from all intermediate angles (light source: Xenon lamp XBO 150W, irradiance 100 µW/cm², visual angle 4°). To test for polarization sensitivity, a polarizer was moved into the optical path and rotated 180° (velocity between 13° and 34°).

In addition a ventrofrontal light-stimulus could be applied (irradiance 5.6 mW/cm², visual angle 7.8°).

Movement sensitivity was tested with a hand-held black and white grating (18 cm x 5 cm, stripes 9 mm wide, distance to animal 5 cm).

Tactile stimuli were applied by gentle brushstrokes on the pronotum, the wings or the cerci.

For evaluation of polarization sensitivity, the 180°-turns were divided into 10° bins. For better visualization the data are shown as double plots from 0° to 360°. A sin²-curve was iteratively fitted to the plot.

To visualize the neurons, they were filled with Neurobiotin at the end of the recordings and then stained using streptavidin horseradish peroxidase conjugate and diamobenzidine. Reconstructions were obtained from brain slices using a camera lucida.

With intracellular recordings combined with Neurobiotin injection, we investigated the physiology and morphology of neurons with ramifications in the AOTU of the desert locust Schistocerca gregaria. Stimulation focused on visual stimuli. Since the branching pattern of some neurons of the AOTu as revealed by dextran injections suggested a participation in the processing of the sky polarization pattern, special emphasis was laid on linearly polarized light.

Neurons from the lower unit of the AOTu

Fig. 3: LoTu1 neuron. The neuron interconnects the lower units (LU) of both AOTUs and has additional branches in anterior lobe of both lobulae. LU upper unit.

Fig. 5: LoTu2 neuron. The neuron interconnects the lower units (LU) of both AOTUs and has additional branches in anterior lobe of one lobula. LU upper unit.

Fig. 7: TuTu1 neuron. The neuron branches in the lower units (LU) of the AOTUs of both brain hemispheres. LU upper unit.

Summary

Neurons from the anterior optic tubercle (AOTu) in the locust brain were characterized, using intracellular recordings and Neurobiotin injection.

Recordings were obtained from six neurons with arborizations in the upper unit of the tubercle and seven neurons of the lower unit.

Neurons from the upper unit connected the AOTUs with wide areas of the protocerebrum. The most prominent projection area was the ipsilateral lateral accessory lobe, which was targeted by five of six neurons. Most of these neurons were tonically inhibited by stationary, unpolarized light but none of them was polarization sensitive.

All neurons recorded from the lower unit connected both AOTUs via the intertubercular tract (TT). Two cell types had additional branches in the anterior lobe of one or both lobulae. All neurons of the lower unit were polarization sensitive and showed polarization opponency, i.e. e-vectors eliciting maximal excitation were perpendicular to e-vectors eliciting maximal inhibition. Stationary unpolarized light lead to tonic or phasic-tonic reactions, most of which were inhibitions.

Neurons from the upper unit of the AOTu in the locust brain cannot be assigned a functional role yet, due to the heterogeneous physiology of the recorded neurons, the lower unit seems to be part of the polarization vision pathway.