SUMMARY

In this thesis I investigated the cellular processing within the primary olfactory neuropil, the antennal lobe (AL), of the honeybee *Apis mellifera*. To this purpose, I developed a new method which allows to measure the net outcome of the AL by selectively staining the output neurons (i.e. projection neurons, PNs) using calcium imaging. I could dissect some important aspects of the cellular network within the honeybee AL: the afferent input is processed by two independent networks, one being PTX-sensitive and thus GABAergic, and serving a global gain control mechanism, the other most likely histaminergic, and mediating an odor- and glomerulus-specific contrast-enhancement. Both these networks are involved in optimizing the representation of odor intensity, odor mixtures and pure substances. Specifically, these findings were described in the following chapters:

I. The calcium activity patterns of PNs to different odors were measured in the honeybee AL. The PN responses were mapped to identified glomeruli, which are the structural and functional units of the AL, to compare the response properties among individuals. The results show that each odor evoked a complex spatio-temporal activity pattern of excited and inhibited glomeruli. These properties were odor- and glomerulus-specific and were conserved across individuals. Comparison to the previously published signals, which derived mainly from the receptor neurons, revealed that the PN responses appeared more confined, showing that inhibitory connections enhance the contrast between glomeruli in the AL. Application of GABA and its receptor antagonist picrotoxin (PTX) to the AL showed the presence of two inhibitory networks (as described above) and led to a proposal about the wiring of the AL network.

II. In order to find the transmitter of the glomerulus-specific and PTX-insensitive inhibitory network, the functional role of the transmitter histamine was analyzed. Thus, the odor representations during histamine application at the input level, estimated by a compound signal, and at the output level, by selectively measuring PNs, were optically recorded. The results show that histamine led to a strong and reversible reduction of the odor-evoked responses of both the input and output neurons, revealing that histamine acts as an inhibitory transmitter in the honeybee AL.

III. Since most naturally odors are complex blends, the representation of binary odor mixtures was investigated in the output neurons. Binary mixtures generally evoked patterns that correspond to simple combinations of the constituent odorants. However, the response intensities of the most responsive glomeruli revealed inhibitory mixture interactions in most animals, which were intensified by PTX application, which silenced the global inhibitory network. This indicates that the observed mixture suppressions emerged from interglomerular computation within the AL.

IV. Honeybees have to recognize odors which occur in plumes at a variety of concentrations. Thus the olfactory system must provide a concentration-invariant code for odor identity. The effect of odor intensity was investigated by simultaneously measuring the input to the AL, estimated by the compound responses, and the output responses of the glomeruli. The results show that increasing concentration generally led to stronger responses and more glomeruli being excited over the AL. Comparison of the input and output responses revealed that the relative responses of specific glomeruli are changed in an odor-specific manner. Weak responses appeared reduced in the output compared to the input, whereas strong responses were even emphasized on the output level. As a result, the AL network modulates and optimizes the afferent input by contrast-enhancing the odor representations, improving discrimination of odor identity at low concentrations, and increasing concentration-invariance of odor-evoked response patterns.