SENSORY ACTIVITY AND FOOD INTAKE:
A STUDY OF INPUT-OUTPUT RELATIONSHIPS
IN TWO PHYTOPHAGOUS INSECTS

by

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SUMMARY

The relationships were studied between sensory responses and behavioural responses to the same stimulus. Sensory and behavioural reactions were both quantified according to stimulus type and concentration. Correlations between relative sensory responses and relative behavioural responses were determined to obtain some insight into processing in the central nervous system.

The larvae of two phytophagous insects were studied: Pieris brassicae L. and Mamestra brassicae L. Pieris is an oligophagous species, restricted to Cruciferae, and Mamestra for reasons of comparison is a polyphagous insect. Phytophagous larvae have three types of gustatory sensilla (present in symmetric pairs), i.e. two pairs (a lateral and a medial) of styloconic sensilla on the maxillae and one pair of epipharyngeal sensilla on the innerside of the labrum. The reactions of these sensilla were measured by recording the impulses elicited by chemical stimuli using electrophysiological techniques. The number of impulses in the first second after onset of stimulation ($N_{sp}$) was counted and served as a measure of sensory activity. Behavioural reactions were measured in feeding tests, in which the larvae (after a starvation period) were fed a test diet containing the stimulus during 24 hours. The dry weight of the faecal pellets produced in this period ($F_p$) was used to quantify the behavioural reaction. The sensory and behavioural responses were combined in relative input-output diagrams (chapter 2).

The responses to the following compounds were determined:
sucrose (in both species)
inositol, a sugaralcohol (in Mamestra only)
sinigrin, representing the glucosinolates, secondary plant substances from the Cruciferae (both species)
strychnine, representing the chemically diverse group of deterrents, secondary plant substances that inhibit food intake (both species)
and the amino acid proline (Pieris only).

Sensory responses, behavioural responses and the correlations between these parameters are presented successively for all compounds for Pieris (chapter 3) and Mamestra (chapter 4). In a number of experiments the effects of ablations (one or more different types of sensilla were eliminated) on the behavioural response have been determined.

In Pieris sucrose evokes a sensory response (an increase in spike frequency) of a cell in all three sensillum types, and it also stimulates food intake. Correlation of the relative sensory response of each sensillum type separately with the relative behavioural response results in non-linear relationships, whereas correlation of the relative total sensory response (responses of the three sensillum types summated) with the relative behavioural response results in a linear relationship. In ablation experiments it
was found that bilateral removal of either one of the three sensillum types did affect the behavioural response to sucrose. Only when all three types of sensilla were ablated simultaneously the behavioural response to sucrose was completely suppressed. Unilateral ablation of both styloconic sensilla, on the contrary, did not affect the behavioural response to sucrose in any way.

In *Pieris* a receptor in the lateral styloconic sensillum responds to stimulation with sinigrin. Sinigrin stimulates food intake, and the behavioural responses to mixtures of sucrose and sinigrin are adequately explained by simple summation of the response to the single components. Thus, no evidence for synergistic effects could be found. Impulse frequency and food intake of the same individual larvae were shown to be positively correlated. Correlation of the relative sensory responses with the relative behavioural responses to sinigrin (using population means, as for sucrose) again resulted in a linear relationship.

Strychnine evokes a response in two sensilla (i.e. the medial styloconic and the epipharyngeal sensillum). Strychnine inhibits food intake, the behavioural response was therefore measured in diets containing sucrose. Plotting the relative behavioural response as a function of the relative sensory response leads to a straight line relationship.

In *Pieris* proline stimulates a cell in the lateral styloconic sensillum. Behaviour was measured on diets containing pure proline or a mixture of sucrose and proline. Behavioural responses showed a clear optimum at $10^{-2}$ M proline. Experiments were not conclusive about the question whether or not the response on the mixture was higher than the summed responses on the components.

In *Mamestra* no electrophysiological evidence could be obtained indicating the presence of some epipharyngeal sensilla. It is assumed, therefore, that *Mamestra* does not possess such receptors. Sucrose and inositol both evoke a response in one type of sensillum (sucrose in the lateral styloconic sensillum, inositol in the medial styloconic sensillum), and both stimulate food intake. Correlation of relative input and output leads to non-linear relationships. After ablation of both styloconic sensilla, the operated larvae still discriminate between a sucrose diet and the control. This suggests that sucrose induces sensory input in some receptors hitherto unknown.

Sinigrin and strychnine both elicit responses in both styloconic sensilla. The two substances inhibit food intake at relatively high concentrations. Correlation of relative sensory responses (summated reactions from both sensilla) and relative behavioural responses (percentage inhibition) results for sinigrin in a linear relationship, and for strychnine in a non-linear relationship.

In chapter 5 the results from *Mamestra* and *Pieris* are compared. The differences are discussed in view of their differences in feeding habits. The following hypothesis relates the behavioural differences to a possible physiological mechanism: *Mamestra* larvae eat considerable amounts of any suitable substrate, and sucrose has only a weak modulating effect. They are also fairly insensitive to feeding deterrents. *Pieris*, on the contrary, eats only a considerable amount when stimulated sufficiently by certain phagostimulants, e.g. sucrose, and is at the same time much more sensitive to feeding deterrents. With regard to the sucrose response in *Pieris*, the results of the ablation experiments and the sensory responses of the receptors are used to discuss some possible ways of combining the inputs from the three sensillum types and from symmetrical sensilla. A model is suggested explaining the way sensory information is processed in the CNS as a basis of feeding activity. The responses to different chemicals are compared, realising the limitations of such comparisons. Some characteristics of the information processing system are discussed, the existence of various channels, the presence of variable thresholds, and $Fp/spike$ ratios.