Sex pheromones and flower odours: how a male moth finds a female in a noisy environment

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(DMNT), an induced volatile used by parasitoids to find hosts, is also key in herbivore deterrence: addition of DMNT to a synthetic cotton mimic suppressed plant odour and pheromone orientation. Using calcium imaging in the antennal lobes, we dissected the neurophysiological basis of this interaction. This revealed that DMNT, at concentrations that did not induce a measurable neurophysiological response alone, attenuated responses to both pheromone and (Z)-3-hexenyl acetate, a known host-plant attractant. Subsequent sensory neuron recordings showed that the suppression of the response to pheromone is peripherally mediated. Apparently, olfactory sensory inhibition, which has previously been reported without reference to an animal's ecology, can be a core part of coding of ecologically relevant odours. As DMNT, and possibly other related synthetic compounds, attract parasitoids and deters herbivores, they may be useful in the development or enhancement of push-pull strategies for sustainable agriculture.

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Moths, like many other insects, communicate using olfactory cues. Females produce a species-specific sex pheromone, which is detected by males over large distances. Male moths also use flower odours to find food or may use host plant odours as additional cues to localize females. Plant-derived odours, present in large amounts in a natural environment, may, however, also represent an olfactory noise, possibly disturbing specific communication.
In the noctuid moth *Agrotis ipsilon*, virgin male attraction to the sex pheromone increases when presented together with a flower odour. However, different plant compounds added to the pheromone during orientation can have different behavioural effects in this species. To elucidate the neuronal mechanisms underlying behavioural effects, we investigated peripheral and central nervous processing of pheromone-plant odour mixtures applied simultaneously or as a background stimulus. Heptanal, a major component of linden flowers, elicited unexpectedly excitatory responses in pheromone-specific olfactory receptor neurons and inhibited responses when added to the pheromone. Extracellular single sensillum recordings revealed that pheromone responses in these olfactory receptor neurons were decreased when applied in a background of heptanal. Pheromone responses in the male-specific part of the antennal lobe, the macroglomerular complex (MGC) were also reduced when applied together with heptanal during optical imaging recordings. Intracellular and extracellular MGC-recordings revealed a reduced response to the pheromone-heptanal mixture as compared to the pheromone alone in a majority of olfactory neurons. These neurons improved their capacity to follow stimulus pulses upon mixture stimulation.
In the plant odour specific part of the olfactory system, no interaction of the sex pheromone with plant odours was found at the antennal level. Plant-specific olfactory receptor neurons did not respond to the pheromone and the pheromone did not modify plant odour responses. This lack of a mixture interaction persisted up to the antennal lobe input level. Calcium responses within the so-called ordinary glomeruli, serving plant odour processing, were not modified by the pheromone. A large proportion of antennal lobe neurons with dendritic arborisations in the ordinary glomeruli, however, responded more strongly to the mixture of heptanal and pheromone than to the pheromone alone, even though only weak responses to the pheromone alone had been observed. Peripheral interactions at the receptor level within the pheromone subsystem and interactions during central processing between pheromone and general odorant subsystems result thus in complex integration of both informations.

A challenging task for a male noctuid moth: scenting the conspecific female sex pheromone in the background of plant volatiles

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Mating is the most critical factor in an insect life to transfer its own genetic material. But finding conspecifics in a complex habitat, which consists of a large variety of different cues, is a difficult task. Like in many other insects, females of the noctuid moth Heliothis virescens (Hv) therefore release chemical cues, a species-specific pheromone blend, to attract mating partners. During evolution males have evolved extremely specialized antennae to detect these volatiles. In Hv one of the pheromone components is the major sex pheromone component Z11-16:Ald. Since there is an enormous amount of volatiles being released from the living environment, we addressed the question, if plant volatiles affect the detection of Z11-16:Ald in male Hv. We could show, that certain plant-related odorants decrease the detection at the level of the olfactory sensory neurons (OSNs) expressing the Z11-16:Ald-receptive odorant receptor HR13. Moreover, via in vivo and in vitro calcium imaging we investigated this suppression effect in a region of the magroglomerular complex of the antennal lobe, where Z11-16: Ald-receptive OSNs terminate. Furthermore,