P156

Aversive learning of tastes in the honeybee

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Honeybees seem to have a limited gustatory repertoire in accordance with a reduced number (10) of gustatory receptor genes identified so far in their genome. The bee gustatory system provides therefore an intriguing model for studies of taste discrimination because of its remarkable difference with that of other insects which are endowed with numerous gustatory receptors. Behavioral studies on taste perception in bees have been restricted to an appetitive framework as the distinctive hallmark used to assess taste responsiveness is the spontaneous extension of the proboscis (proboscis extension response or PER) upon antennal, tarsal or buccal contact with sucrose and other sweet tastants. Aversive substances do not elicit PER so that their perception can only be assessed indirectly, via PER inhibition following sucrose stimulation. The study of taste perception and discrimination is limited by the fact that sucrose acts as an unconditioned stimulus (US) eliciting a spontaneous unconditioned reaction. A fundamental step is, therefore, to overcome the traditional US status of tastants and to conceive conditioning forms in which they act as conditioned stimuli (CS). Here we present the first gustatory conditioning protocol in bees in which tastants are used as CSs and in which reinforcement is strictly dissociated from gustatory input. We took advantage of the sting extension response (SER), which can be elicited in harnessed honeybees by a mild electric shock. We developed a new conditioning protocol in which tastants are delivered to the antennae and paired with electric shock in order to induce gustatory conditioning of SER. We thus provide the first study of taste learning and discrimination in which, contrary to other attempts, taste perception is clearly separated from ingestion. Our results reveal principles of within- and between-taste perception in bees and open new perspectives for the study of the biology of taste in insects.