© 2020. Published by The Company of Biologists Ltd | Journal of Experimental Biology (2020) 223, jeb239384. doi:10.1242/jeb.239384

INSIDE JEB

Bee brains transform scent cocktails

A honey bee (*Apis mellifera*) feeding on flowers at Çukurova University Campus, Adana, Turkey. Photo credit: Zeynel Cebeci/CC BY-SA (https://creativecommons.org/licenses/by-sa/4.0).

In the nostrils of a sommelier, the bouquet of a classic vintage can provoke descriptive outbursts, ranging from blackcurrant overtones to hints of vanilla. Although many odours can combine to produce a fragrance where individual scents can still be distinguished, some scents magically assemble in our sensory system to produce a completely novel aroma. For example, the combination of ethyl isobutyrate and ethyl maltol smells of pineapples, even though the individual components smell of strawberries and caramel, respectively. 'The ability to treat a mixture as a distinct odour, a new entity, is called configural processing', says Jean-Christophe Sandoz, from Université Paris-Saclay, France, adding that his colleagues Gerard Coureaud (Centre de Recherche en Neuroscience, France) and Thierry Thomas-Danguin (Université Bourgogne Franche-Comté) had discovered that adult rats, mice and rabbit newborns are also capable of perceiving certain odour combinations as more than the sum of their parts. However, Sandoz also knew that the structure of the brain regions dedicated to the sense of smell are remarkably similar in insects and mammals, which made him wonder whether honey bees also have the ability to recognise odour combinations as unique scents.

First, Sandoz and Marie-Anne Wycke trained bees to extend their proboscises when they recognised an odour, such as ethyl isobutyrate, ethyl maltol or a combination of the two. Wycke then tested the bees' responses to the individual components and blend to find whether they picked up the mixture, having learned the scent of the individual components, or failed to recognise the mixture, because their sense of smell transformed the blend into a completely different scent.

However, the bees that were trained to recognise the individual components still stuck out their proboscises when the combined odours wafted over their antennae. In addition, some of the bees recognised the individual odours even though they had been trained to extend their proboscises in response to the blend of the two. Even when Wycke trained bees to recognise combinations of ethyl isobutyrate with guaicol, ethyl maltol with guaicol and combinations of floral scented compounds, the bees were still able to identify the components in each mixture. They didn't seem to perceive the combinations as completely novel scents.

However, Sandoz knew that bees can be trained to ignore a scent that smells different from other odours by learning to focus on the different way that the combination of odours lights up the nerves in their mini brains. Could the bees learn to recognise odour combinations as completely different smells?

This time, Wycke provided the bees with a rewarding sip of sugar whenever they sniffed the individual components (either ethyl isobutyrate or ethyl maltol), but withheld the reward whenever the bees smelled the combination. At first, the bees extended their tongues enthusiastically when they smelled the scent combination. However, by the time Wycke provided the bees with a sixth series of sniffs, the bees had figured out that the combo was different from the individual components and ignored it, keeping their proboscises tucked away. In their minds, the cocktail was different from the individual components. And when Wycke repeated the experiments with four other scent combinations, the insects learned that the blend smelled different from the components in three cases.

In other words, bees can learn that a combination of scents produces a completely different odour from the sum of its parts, and Sandoz is keen to find out how the patterns of nerves signalling each odour and their cocktails differ, in the hope of gaining insight into the paradox that transforms strawberries and caramel into pineapple in our brains.

10.1242/jeb.239384

Wycke, M.-A., Coureaud, G., Thomas-Danguin, T. and Sandoz, J.-C. (2020). Configural perception of a binary olfactory mixture in honey bees, as in humans, rodents and newborn rabbits. *J. Exp. Biol.* **223**, jeb227611. doi:10.1242/jeb.227611

Kathryn Knight
kathryn.knight@biologists.com

Inside JEB highlights the key developments in Journal of Experimental Biology. Written by science journalists, each short report gives the inside view of the science in JEB.