



Culture in bumblebees

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A recommendation of

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This is an original paper [1] addressing the question whether cultural transmission occurs in insects and studying the mechanisms of such transmission. Often, culture-like phenomena require relatively sophisticated learning mechanisms, for example imitation and/or teaching. In insects, seemingly complex processes of social information acquisition can sometimes instead be mediated by relatively simple learning mechanisms suggesting that cultural processes may not necessarily require sophisticated learning abilities.

An important quality of this paper is to describe neatly the experimental protocols used for such typically complex behavioural analyses, providing a detailed understanding of the results while it remains a joy to read. This becomes rare in high impact journals. In a clever experimental design, individual bumblebees are trained to pull an artificial flower from under a Plexiglas table to get access to a reward, by pulling a string attached to the flower. Individuals that have learnt this task are then shown to inexperienced bees while performing this task. This results in a large proportion of the inexperienced observers learning to pull the string and getting access to the reward. Finally, the authors could then document the spread of the string pulling skill amongst other workers in the colony. Even when the originally trained individuals had died, the skill of string-pulling persisted in the colony, as long as they were challenged with the task. This shows that cultural transmission takes place within a colony. The authors provide evidence that the transmission of this behavior among individuals relies on a mix of social learning by local enhancement (bees were attracted to the location where they had observed a demonstrator) and of non-social, individual learning (pulling the string is learned by trial and errors and not by direct imitation of the conspecific). Data also show that simple associative mechanisms are enough and that stimulus

enhancement was involved (bees were attracted to the string when its location was concordant with that during prior observation).

The cleverly designed experiments use a paradigm (string-pulling) which has often been used to investigate cognitive abilities in vertebrates. Comparison with such studies indicate that bees, in some aspects of their learning, may not be different from birds, dogs, or apes as they also relied on the perceptual feedback provided by their actions, resulting in target movement to learn string pulling. The results of the study suggest that the combination of relatively simple forms of social learning and trial-and-error learning can mediate the acquisition of new skills and that bumblebees possess the essential cognitive elements for cultural transmission and in a broader sense, that the capacity of culture may be present within most animals.

Can we expect behavioural innovation such as string pulling to occur in nature? *Bombus terrestris* colonies can reach a total of several hundreds foragers. In the experiments, foragers needed on average 5 rounds of observations with different demonstrators to learn how to pull the string. As individuals forage in a meadow full of flowers and conspecifics, transmission of behavioural innovations by repeated observations shouldn't strike us as something impossible. Would the behavior survive through the winter? Bumblebee colonies are seasonal in northern areas and in the Mediterranean area but tropical species persists for several years. In seasonal species, all the workers die before winter and only new queens overwinter. So there is no possibility for seasonal foragers to transmit the technique overwinter. Only queens could potentially transmit it to new foragers in spring. However flowers are different in autumn and spring. Therefore, what queens have learnt about flowers in autumn would unlikely be useful in spring (providing that they can remember it). However there is no reason why the technique couldn't be transmitted from a colony to another between spring to autumn. Such transmission of new behaviour would more easily persist in perennial social insect colonies, like honeybees. Importantly, the bees used in these experiments came from a company whose rearing conditions are unknown, and only a few colonies were used for each experiment. As learning ability has a genetic basis [2-3], colonies differ in their ability to learn [4]. In this regard, the authors showed variation between individual bumblebees and between bumblebee colonies in learning ability. Hence, we would wish to know more about the level of genetic diversity in the wild, and of genetic differentiation between tested colonies (were they independent replicates?), to extrapolate the results to what may happen in the wild.

Excitingly, the authors found 2 true innovators among the >400 individuals that were tested at least once for 5 min who would solve such a task without stepwise training or observation of skilled demonstrators, showing that behavioural innovation can occur in very small numbers of individuals, provided that an ecological trigger is provided (food reward). Hence this study shows that all ingredients for the long proposed "social heredity" theory proposed by Baldwin in 1896 are available in this organism, suggesting that social transmission of behavioural innovations could technically act as an additional mechanism for adaptive evolution [5], next to genetic evolution that may take longer to produce adaptive evolution. The question remains whether the behavioural innovations are arising from standing genetic variation in the bees, or do not need a firm genetic background to appear.

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