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Randomness forms complex social structures

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Chance plays a significant role in the establishment and maintenance of social structure in a population of wild mice. Credit: Nicolas Perony/ETH Zurich

(Phys.org)—The environment of group-living animals influences their social behaviour in a stronger way than was previously thought, says a new study from behavioural researchers at ETH and the University of Zurich. They thereby support the very counterintuitive argument that randomness is responsible for the establishment and the maintenance of social networks.

Group living is a model of success: many animals, including man itself, live in social organisations, which from species to species follow different rules, and serve different ends.

Much is known today about the evolutionary benefit of group living; however, comparatively little knowledge exists of the precise mechanisms which govern the behaviour of individuals in a group, and allow them to build and maintain social bonds with their conspecifics. Behavioural scientists set out to measure the influence of chance alone in this social behaviour.

With a new model, which has just been published in *PLoS Computational Biology*, researchers from the Chair of Systems Design at ETH Zurich, along with behavioural biologists from the University of Zurich, support the argument that randomness plays a major role in the establishment and the conservation of social structures. They came to this conclusion by recording and analysing the movement and social interaction patterns of individual mice in a wild population.

Monitoring the mice

The mouse population was established in 2003 with the introduction of nine animals to an empty barn near Zurich. Since then, the population has grown to a few hundred individuals, organised in several subgroups. The barn is divided into several segments, with transit holes between them. The rodents can visit or leave the building at any time. The researchers provide the mice with nest boxes, nesting material, food and water. There are no natural predators living in the barn.

Every adult mouse is equipped with an electronic chip, which makes it possible to know when the animal entered or left a nest box, as well as how long it spent inside the nest. By this means, the researchers collected over two years millions of location records for over 500 individuals, which were used by Nicolas Perony, postdoctoral researcher at the Chair of Systems Design, to extract activity patterns for each individual.

Because the electronic chips only recorded how long a mouse spent when it was outside of a nest, but not where it went or which part of the environment it effectively used, he could only compute the probability with which the mouse could be present in a given location at a given time. He represented this probability in a three-dimensional map: if the mouse takes the shortest route from nest A into nest B, its trajectory will thus be pictured as a narrow trench. If, however, the mouse spends two hours in between the two nests, its probable location will take the form of a broad valley: during the two-hour period, the mouse could have been present at any point within the valley.

A novel way to describe habitat use

Perony merged all these computations into a single "perceptual landscape". "This three-dimensional map is a novel tool which to a certain extent describes how the walls separating the different segments of the barn restrict the freedom of movement of the animals", he explains. The perceptual landscape also contains an additional layer, which has to do with the perception of the animals: for example, the tendency that the mice have to avoid the territory of an enemy. Furthermore, a normal map represents all nests in the barn as equal. By contrast, the perceptual landscape models the mice's favoured nests as deeper holes in the landscape.

Based on this description, Perony observed that the mice indeed strongly use spatial features in their environment to orientate themselves. However, exactly how strongly the landscape – and ultimately randomness – affected their social structure was not clear. To this end he created a computational model, in which he introduced random agents to the generated perceptual landscape.

Random particles with a social structure

In order to define the "behaviour" of these agents, Perony used real data: from the behaviour of all the mice he extracted the average movement speed and the average stay duration in each nest, and applied these to the particles entering the nests and circulating between them. The random particles were socially passive: they contained no idiosyncratic properties, and obeyed no rule of attraction for a particular territory or another particle; they could not interact with the other particles either.

The result of Perony's simulations came to him as somewhat of a surprise: the social structure created by the model was in many aspects not significantly different to the one extracted from the behavioural data. "It seems that rather much of what we label as socially complex can instead by explained by passive interactions of individuals with their environment", he says.

Reduced free will

Random particles, whose behaviour was constrained by a non-random environment, could reproduce the social structure of the real mice rather fittingly. "The environment may determine an individual's social interaction pattern to a greater extent than one would like to think", summarise the researchers. One's freedom of choice, with which one creates and maintains social bonds, may thus be more limited than one thinks.

The model is however limited insofar as it does not take into account cases in which two mice are explicitly attracted to one another, and as a consequence often visit the same nest. The quantity of "social attraction between two animals" overrules their "personal preference for a particular nest". This quantity could not be reproduced through the interaction between the animals and their environment. "The explanation is therefore to be sought in behaviours that are explicitly social", argues the researcher.

This study is part of Nicolas Perony's doctoral dissertation, for which he received the ETH medal.

More information: Perony N, Tessone CJ, König B, Schweitzer F. How Random Is Social Behaviour? Disentangling Social Complexity through the Study of a Wild House Mouse Population, *PLoS Computational Biology* (2012), published online 29th November. doi:10.1371/journal.pcbi.1002786

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