Neurons in crows' brains signal which pictures belong together

November 27 2015

Crows learned to sort arbitrary images into two color groups. Individual neurons responded to images according to which group the images belonged in - regardless of what the image was. Credit: Lena Veit

During learning, cells in the crow brain acquire discharge patterns that associate pictures with their meaning.

It's long been established that crows are quick to make connections; Their remarkable behavioral flexibility and adaptability allows them to

navigate our cities and learn to work with traffic signals, figure out who will give them nuts - and which humans are best avoided. Researchers at the University of Tübingen have now shown how crow brains master such learning tasks. Their findings are published in the latest *Proceedings of the National Academy of Sciences* (*PNAS*).

Crows were given the task of sorting arbitrary images into two groups. For example, they were required to peck at a red square after seeing a picture of a bird, but to peck a blue square after seeing a flower. At first, the crows needed to learn by trial and error, by guessing which pictures belonged to which color group. By earning reward for each correct choice, the crows quickly learned the correct associations for each picture.

The researchers recorded neuronal activity in a brain area called nidopallium caudolaterale (NCL), which is thought to mediate flexible behavior and cognition in birds. Some neurons responded differentially to different pictures. Importantly, there were neurons which grouped the pictures according to the required response: For example, one neuron would preferentially respond to all pictures associated with the "red" response, even if those pictures looked completely different. This means that the neurons did not store individual pictures' appearance in working memory, but instead the groups associated with the pictures. It made no difference whether the crows had only just learned the correct group or whether they had known the correct response for weeks.

By recording neuronal activity during the learning process, the researchers could show that this selectivity appears within minutes as the crow is learning the meaning of new pictures. "It's quite amazing how fast the crows can learn to make these associations - and how we can watch single neurons during the learning process," says the study's lead author, Dr. Lena Veit. "Many neurons would barely respond to an unfamiliar image during the 'guessing' part of learning. But after a few

tries, as soon as the crow has learned the right grouping, these neurons strongly indicated the correct response for the same image."

This kind of storage in working memory makes sense. The birds don't have to remember as many details, and they are prepared for the correct answer straight away. "We knew that this kind of working memory processing existed in primates," says project leader Professor Andreas Nieder. "It is remarkable that we are finding such similar learning strategies in the dissimilar endbrains of birds and mammals." However, the researchers did find small differences to learning in mammals. "Now, our big question is what the divergent brain organization means for the cooperation of multiple brain regions during the learning process ?"

More information: Lena Veit et al. Associative learning rapidly establishes neuronal representations of upcoming behavioral choices in crows, *Proceedings of the National Academy of Sciences* (2015). DOI: 10.1073/pnas.1509760112

Provided by Universitaet Tübingen