Birds and primates share brain cell types linked to intelligence

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Neuronal cell types in the brains of birds linked to goal-directed behaviors and cognition are similar to cells in the mammalian neocortex, the large, layered structure on the outer surface of the brain where most

higher-order processing takes place.

In a new study, published this week in the journal *Current Biology*, scientists from the University of Chicago show that some neurons in bird brains form the same kind of circuitry and have the same molecular signature as cells that enable connectivity between different areas of the mammalian neocortex. The researchers found that alligators share these cell types as well, suggesting that while mammal, bird and reptile brains have very different anatomical structures, they operate using the same shared set of brain cell types.

"Birds are more intelligent than you think, and they do clever things. So, the question is: What kind of brain circuitry are they using?" said Clifton Ragsdale, PhD, professor of neurobiology at UChicago and senior author of the study. "What this research shows is that they're using the same cell types with the same kinds of connections we see in the neocortex, but with a very different kind of organization."

Both the mammalian neocortex and a structure in the bird brain called the dorsal ventricular ridge (DVR) develop from an embryonic region called the telencephalon. However, the two regions mature into very different shapes. The neocortex is made up of six distinct layers while the DVR contains large clusters of neurons called nuclei.

Because of this different anatomy, many scientists proposed that the bird DVR does not correspond to the mammalian cortex but is instead analogous to another mammalian brain structure called the amygdala.

In 2012, Ragsdale and his team confirmed a 50-year-old hypothesis by University of California San Diego neuroscientist Harvey Karten that proposed the DVR performs a similar function to the neocortex, but with dramatically different anatomy. In that study, the UChicago researchers matched genetic markers of the "input" and "output" neurons of the

mammalian neocortex with genes expressed in several bird DVR nuclei.

In the new study, led by graduate student Steven Briscoe, the team found that other populations of neurons in the bird DVR share molecular signatures with neocortical intratelencephalic cells, or IT neurons. These IT neurons form a critical link in the circuitry of the neocortex. They help communicate between different neocortical layers and across cortical areas from one side of the brain to the other. The team then extended their work from birds to reptiles and identified IT neurons in a similar place in the alligator DVR.

"The structure of the avian DVR looks nothing like the mammalian neocortex, and this has historically been a huge problem in comparative neuroscience," Briscoe said. "Anatomists have debated how to compare the DVR and neocortex for over a century, and our identification of IT neurons in the bird DVR helps to explain how such different brain structures can give rise to similar behaviors."

The research suggests an interesting possibility that birds and primates evolved intelligence independently, developing vastly different brain structures but starting with the same shared sets of cell types.

"The input cell types, the output cell types and the intratelencephalic cell types are all conserved. They're not just found in mammals, which we knew, but in non-avian reptiles like alligators and avian reptiles, or birds," Ragsdale said. "It begins to clarify where and how in evolution we got this fantastic structure, the neocortex."

More information: "Neocortical association cell types in the forebrain of birds and alligators," *Current Biology* (2018).

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