The Secrets behind a Corvid's Intelligence

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1. Introduction

- Corvids are a casual term for birds in the *Corvidae* family. They are as intelligent as seven-year old children.
- *Corvidae* consists of crows, rooks, jackdaws, jays, ravens, magpies, treepies, choughs and nutcrackers.[1]
- They have the largest brains for their body size of any bird.[5] The crow brain is the same relative size as the chimpanzee brain.
- They are the only known non-primates to make tools such as prodding sticks and hooks to prod out grubs. (Figure 3)
- Intelligence is the ability to adapt to novel environments, problem-solve and abstract general principles for decision-making and creativity.[2]
- The study of avian cognition may reveal how different brain structures achieve complex cognition (between primates and corvids).
- This may ultimately help us understand the requirements and constraints for a highly cognitive brain and create/ improve artificial intelligence.
- Why are corvids smarter than other avian species?
- What is the neurological basis for their intelligence?
- What drives the evolution of their relatively big brains?

Figure 1. Crows are considered "feathered apes" by many behavioral biologists, due to their large brain sizes and intelligent behavior.
Image from: http://www.sciencedaily.com

2. Mirror test shows magpies aren't so bird-brained

- The European magpie (pica pica) is able to recognize itself in the mirror, demonstrating self-recognition.
- It is worthy to note that the European magpie is the only bird to pass the mirror self-recognition test.
- A few primates (chimpanzees and orang-utans) have also passed the mirror test.
- Figure 2 below illustrates a magpie passing the mirror test, successfully recognizing itself, and demonstrating self-awareness.

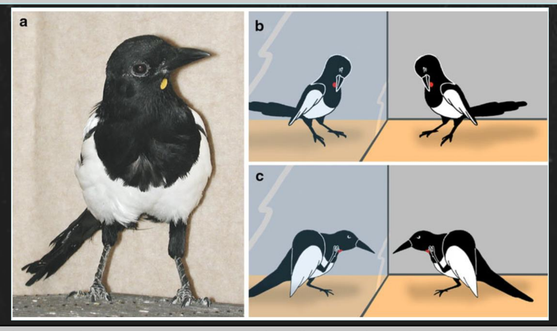

Figure 2. (a) Magpie *pica pica* with yellow mark on throat. (b),(c) Schematic depictions of magpie's attempt to remove marking after seeing its reflection in the mirror.[4] Demonstrating self-awareness.

3. Scientists identify area responsible for bird "smarts"

- Neurobiologists for the first time find out how a non-mammalian brain works, and this pattern may apply for alien life.
- Neurobiologists Lena Veit and Andreas Nieder published an article in Nature communications in 2013 to reveal their findings about corvid intelligence.
- In their experiment two carrion crows were trained to carry out memory tasks on a computer touch screen.
- They were shown a picture and then had to pick out the same one from two pictures after a delay period (match rule).
- Sometimes it was to choose the different image, according to the cues presented (non-match rule).
- The crows were able to complete and switch between both tasks with high accuracy (above 90% of the time).
- This demonstrates their mental flexibility and their ability to abstract general principles to aid in decision-making.
- Observing their brain activity, the same set of neurons fired when they had to choose the same image.
- Another set of neurons fired when they made a choice based on the "different picture" rule.
- Researchers could predict the corvid's decision by just looking at their neural activity.
- It was thus suggested that the nidopallium caudolaterale (NCL) was the neuronal foundation of corvid cognition.
- Figure 4 is a schematic diagram of the experiment. The cue for the nonmatch was either a red circle or an auditory upward sweep.
- The cue for the match was a blue circle or a burst of white noise.

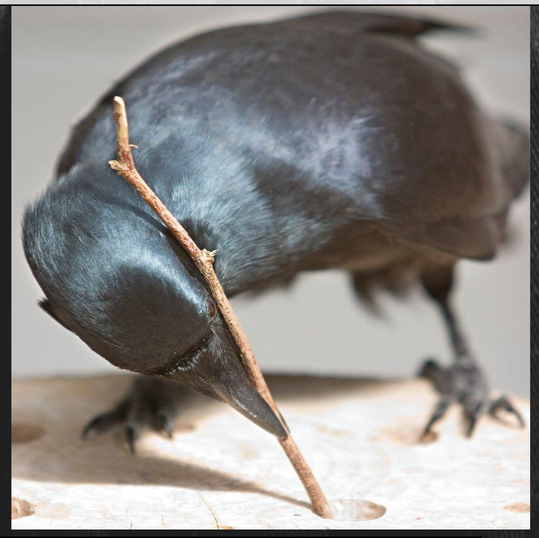

Figure 3. A New Caledonian crow using a twig to dislodge beetle larvae from a tree trunk. Crows that are good tool users have better access to highly nutritious food.
Image from: http://www.nytimes.com

"If men had wings and bore black feathers, few of them would be clever enough to be crows."
—Henry Ward Beecher, mid 1800s

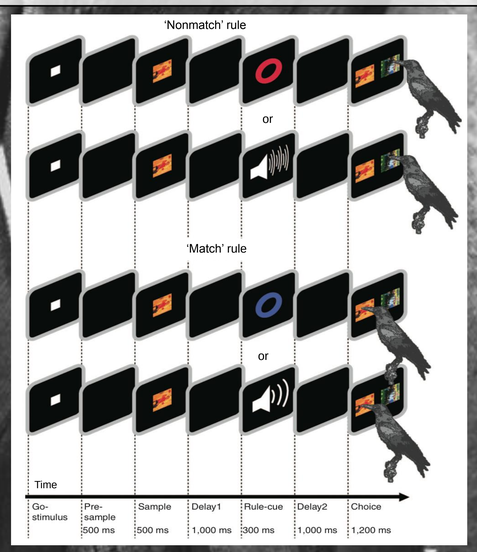

Figure 4. The carrion crow experiment, where crows were to peck at identical or different pictures according to the current rule signified by the cue.[3] (modified)

4. The Driving Force behind their Big Brain

- Cognitive capabilities of corvids are impressive and rival and sometimes exceed those of primates.
- Avian NCL shares many characteristics and functions with the mammalian prefrontal cortex (PFC).[4]
- NCL and PFC are functional analogues, independently evolved from different ancestors through convergent evolution.[4]
- This suggests that there is only a limited solution for the realization of higher cognitive functions.[4]
- Figure 5 shows the avian brain lacking lamination but still achieving the same functions.
- This suggests that lamination cannot be a requirement for complex cognition.[4]
- Due to the similar challenging environments corvids and primates live in; they evolved similar neural structures for complex cognition.[6]
- Ancestors of corvids had already evolved large brains and were moderate food-cachers.[6]
- Corvids require altricial development, bi-parental care, develop complex social relationships, and exchange affinitive behaviours.[10]
- Food caching allows for bigger hippocampal volume compared with non-food caching.[8]

Figure 5. Side view of a human brain and a pigeon brain (right). The smaller brain in the middle is the pigeons' brain in proper scale. The PFC is the prefrontal cortex and the NCL is the nidopallium caudolaterale.[4]

5.Conclusion

- The nidopallium caudolaterale (NCL) is the neuronal basis of complex corvid cognition.
- The NCL is the functional analogue to the mammalian PFC.
- Both structures convergently evolved from different ancestors for complex cognition.
- Lamination is not a requirement for intelligence.
- Corvids require bi-parental care, pair bonding, stable social relationships and altricial development.
- This is crucial for the development of a big brain.
- The ancestors of corvids had already evolved large brains and were moderate cachers.
- Caching food items allow them to develop larger hippocampal volumes.
- Understanding how intelligence works in two species with different evolutionary origin might help us advance artificial intelligence.

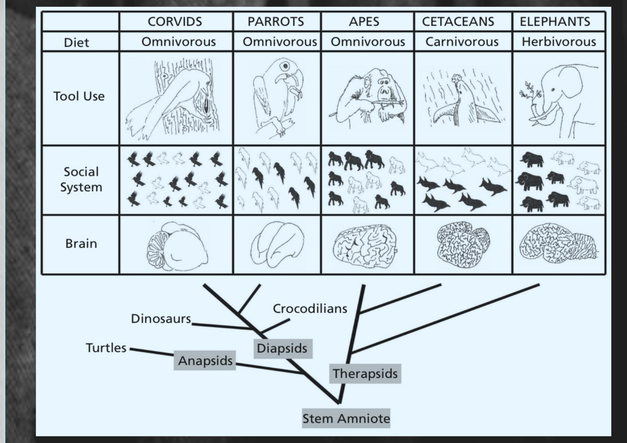

Figure 6. The common characteristics of big-brained animals and their evolutionary relationships.[9] (modified)

6. References

1. Dos Anjos L: Family Corvidae (Crows). Handbook of the Birds of the World Bush-shrikes to Old World Sparrows 14:494–641.
2. Student definitions of intelligence (2003, Jul 28). Retrieved from http://www.wilderdom.com/personality/L1-6StudentDefinitions.html
3. Veit Lena and Nieder Andreas. 2013. Abstract rule neurons in the endbrain support intelligent behaviour in corvid songbirds. Nature communications
4. Güntürkün Onur. 2005. The avian 'prefrontal cortex' and cognition. Current Opinion in Neurobiology 15:686-693.
5. Emery J. Nathan, Clayton S. Nicola. 2004. The mentality of crows: convergent evolution of intelligence in corvids and apes. Science New Series 306(5703):1903-1907.
6. Jønsson A. Knud, Fabre Pierre-Henri and Irestedt Martin. 2012. Brains, tools, innovations and biogeography in crows and ravens. BMC Evolutionary Biology 12:72.
7. Emery J. Nathan. 2006. Cognitive ornithology: the evolution of avian intelligence. Philosophical Transactions: Biological Science 361(1465):23-43.
8. Grodzinski Uri and Clayton S. Nicola 2010. Problems faced by food-caching corvids and the evolution of cognitive solutions. Philosophical Transactions of the Royal Society 365:977-987.
9. Van Horik O. Jayden, Clayton S. Nicola and Emery J. Nathan. 2011. Convergent evolution of cognition in corvids, apes and other animals.
10. Emery J. Nathan et al 2007. Cognitive adaptations of social bonding in birds. Phil Trans. R. Soc. B 362:489-505.

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