# Who Are You Calling Birdbrain?

By Margie Athol

*Crow by "skeeze" on pixabay*

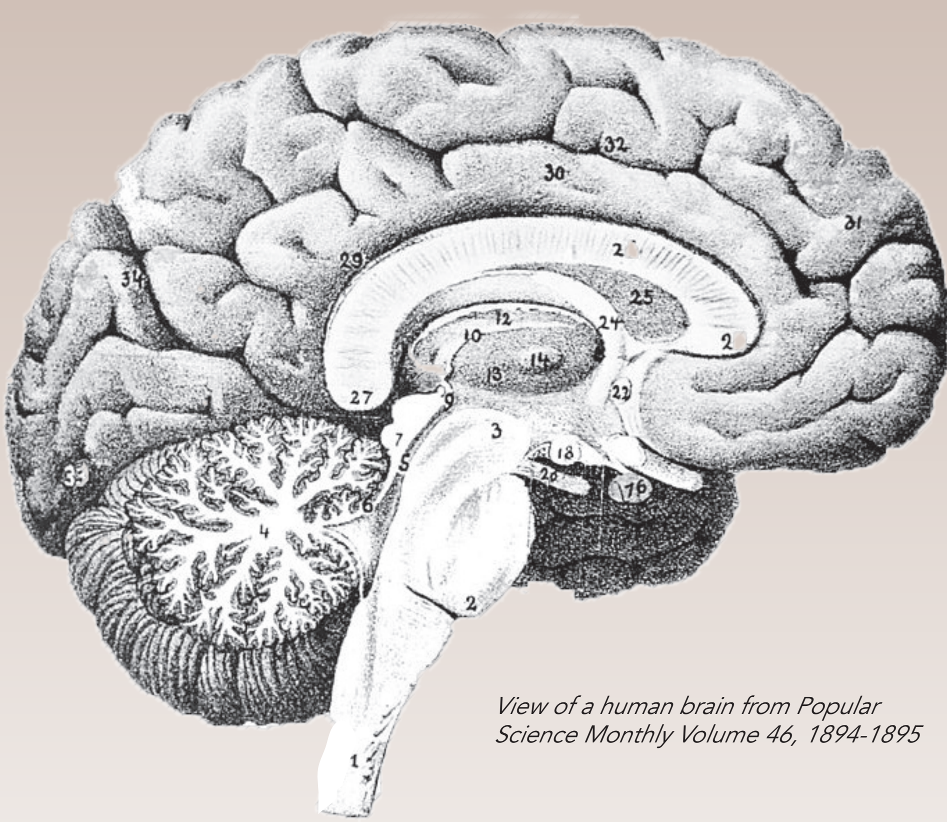
Most of us have heard or used the expression "birdbrain". Dating back to the early twentieth century, to call someone "bird-brain" is to call them, simple, unintelligent, or stupid. But despite how birds may be perceived, they aren't deserving of the moniker coined from them. From being able to navigate unfamiliar territory, to using tools to hide food for future consumption, birds engage in many behaviors that require a highly skilled brain. Birds are, dare I say, very smart.

## But what is "intelligence"?

When we say "smart", what do we mean? When turning to the Merriam-Webster English Dictionary, searching for "smart" lead me to "clever", defined as "mentally quick or resourceful". And what for "intelligence"? There are two relevant definitions, the first being, "the ability to learn or understand or to deal with new or trying situations" and the second, "the ability to apply knowledge to manipulate one's environment or

*Image from "Illustrated British Ballads, old and new" by SMITH, George Barnett 1886 on Flickr*

to think abstractly as measured by objective criteria (such as tests)". Both of these definitions have to deal with flexibility. Intelligence is all about possessing the mental flexibility to learn or to apply



*View of a human brain from Popular Science Monthly Volume 46, 1894-1895*

knowledge to new situations. Now the end of that second definition is critical: "measured by objective criteria". And that is where birds aren't getting a fair shake.

People are, naturally, as all animals are, centered on themselves. We think of everything in terms of how it compares to us or to humans. So when people try to study things like animal intelligence or cognition, there is a tendency to create a single scale on which all creatures are placed (and humans are at the end of "smartest"). But intelligence evolved independently among multiple taxons; it didn't evolve in a straight line culminating with humans as some theorize.

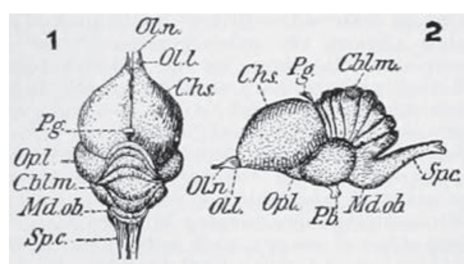
Animal cognition—the study of non-human animal mental capacities and, in some ways, intelligence—is typically studied through behavioral tasks and tests. While there is success in crafting tasks that an animal could physically do, the concept behind many tests comes down to logic along the lines of "how well does this animal do at this human task?". If we are only going to use the scale of human intelligence, this isn't a bad way to do it, and it is often how we arrive to conclusions like dogs having the mental capacity of a young child. Yet to really get at the intelligence of non-human animals, we should be analyzing how they face challenges they might experience in their natural environment.

Yet when we talk about smarts, a colloquial analogy is "brains". If we try to define intelligence by brain properties, what do we find?

## Having a lot of brains isn't the whole story…

The brain is responsible for everything we do from brushing our teeth to doing our math homework. When we talk about someone really smart we might say they have a big brain because we equate a larger brain with intelligence. The story of how we made that conclusion is an interesting one. When looking at hominid evolution, we see that the size of our brains increased rapidly and drastically. And since the increase in brain size was accompanied by an increase in hominid intelligence, it was thought that a bigger brain meant a smarter animal. We know this isn't true when we take into account examples such as the chimpanzee which is smarter than a walrus but with a brain a third of the size. And humans—supposedly the smartest animal—have a brain less than half the size of an African elephant[1]. But there is a trend you might've noticed: each of the aforementioned smarter animals is much smaller than the counterpart. So maybe it is about relative brain size. When we look at relative brain size, we see that while absolute brain size increases with body mass, relative brain mass actually decreases. What about when we get more specific?

The cortex is thought to be the "smart" part of the brain because it is the most flexible part of the brain—it changes readily in response to experience. One particular area of interest is the prefrontal cortex (PFC), which is the area responsible for reason and action planning. The challenge with using the PFC as a point of comparison is that its bounds are challenging to define, meaning results aren't as accurate[1]. The next step, then, was to think not only about shape and size, but also the




*Drawing of an avian brain adapted from The New International Encyclopædia, v. 3, 1905, p. 102. by Ernest Ingersoll* number of neurons.

Neurons are cells of the brain that work in electrical impulses. When we talk about what the brain does, we are really talking about what a system of neurons is accomplishing. The thought is then that if you have more neurons, you could be smarter. Because neurons work in electrical impulses, when we talk about their conduction, we can think of it like wires in an electrical circuit. For intelligence, we want neurons that send signals quickly. In a wire, it will send a signal faster if the wire is thicker, if it is well insulated, and if the distance it has to travel is shorter. The same principles apply to neurons. Neurons that have thicker axons (the wire) with more myelin (the insulation) and are closer together will lead to a smarter animal. This concept is called Information Processing Capacity (IPC). IPC is a better measure than overall or relative size. And we see that animals that are more intelligent have a higher IPC. The most common comparisons are made among mammals, for example, a bushbaby has more neurons than a marmoset which has more neurons than a rat and a chimpanzee more than any of them[1]. But when we compare birds to mammals, we see that birds win each time. When comparing the number of cortical neurons, birds have over double the number of neurons of a similarly sized mammal counterpart. This is likely possible because while both "smart mammals" and birds have tightly packed neurons, birds have smaller neurons meaning more neurons can be packed into the same volume[2]. One showdown of IPC we can look at is comparing the brain of the raven to the capuchin monkey. While the raven's cortex weighs a quarter of what the capuchin monkey's weighs (10 versus 40 grams), the raven has more neurons with 1,204 million neurons in its cortex compared to the capuchin's 1,140 million[3].

Another structure we can look at when considering intelligence is the hippocampus. It's responsible for functions of memory and long-term memory and damaging the hippocampus leads to difficulty in forming new memories. And while it makes sense to look at this structure (since mental flexibility requires the manipulation of memory), when we try to correlate its overall size to intelligence, we see that it doesn't give us a clean answer. For example, birds that are able to store large amounts of food and remember the many locations don't always have larger hippocampi[3].

We could look at more subtle features such as the morphological diversity of cortical cells or we could look at cell architecture. But what would any of these differences tell us? It is difficult to say, but we can see that general trends and correlations won't tell us the whole story. So we need to take a look at what these structures allow animals to do.

And the brains of birds—despite being small—allow them to accomplish impressive feats. I'm going to look at three examples of birds that make the most of their bird brains and exhibit intelligence.

## Crows

Crows are part of the corvid family, which are regarded as the most intelligent birds, even displaying self-recognition in mirror tests and using tools—two skills that we thought for a long time belonged only to humans and a select few other mammals. Corvids are marked by their strong bills and feet and can be found across the world except for the polar ice caps and tip of South America. Crows, specifically, are easily recognized by their dark black feathers or by their distinctive squawking. In the last few years they have become a fascination of many and viral videos on the Internet as they display skills that we don't expect birds to possess.

*Image from "B.C. 1887 A ramble in British Columbia. By James Arthur Lees. 1888. On Flickr.*

*Illustration from the Archives of Pearson Scott Foresman. artist unknown.*

## The Short End of the Twig

Many people know that crows use tools. There are plenty of videos on YouTube of crows solving puzzles, but let's stop to think about what they are accomplishing and what goes into solving a puzzle. Let's say a crow needed to choose one of three twigs to reach a rock. The crow then needs to put the rock on a lever which will open a door leading to a piece of food. First, the crow needs to be able to know how to use a twig to reach another object. The crow has to understand that it can use an object to take effect on another object. It then has to understand that twigs can be different lengths which provide a different amount of reach. The crow can do this pretty easily. The next step that the crow is able to understand is that when the lever is held down, food is revealed and the rock can hold down the lever. This requires object permanence as well an understanding of a complex relationship between two events (the pushing down of a lever and the opening of a door). The fact that the crow is able to complete a man-made puzzle with relative ease is impressive. But like I mentioned earlier, a bird wouldn't need to solve a puzzle like this in the wild, so it isn't necessarily a fair assessment.

Hunt, Rutledge, and Gray in 2006 published a study examining tool use by crows. In the study, they went into the forest and drilled a hole in some branches: large enough to fit some food, but small enough for a crow to be unable to reach inside. They then placed various twigs and leaf pieces around the branch for crows to use. What they found was that crows were able to select a tool based on length and based on the food they were trying to get. The crow would choose a twig that was long enough to reach the food while still having control. And if the crow chose a twig that was too short or long, it would adjust accordingly and pick a new tool. The food placed in the branch was either a live grub or a dead grub. The crows could use a smooth twig to get living grubs because upon being poked, the grubs would hang on to the stick. With a dead grub, however, the crows used a spiny twig to drag the grub out[4].

Crows display incredible flexibility when it comes to their tool use. They can use a twig as an extension of their own limbs, but moreso, they have the ability to identify the specific qualities of that tool that are effective or need to change.

## Hell hath no fury like a corvid scorned

Crows are very social creatures. Cornell, Marzluff, and Pecoraro studied social learning in crows in a 2012 study. Crows engage in a behavior called scorning—when a crow will follow and squawk at animals who are a threat accompanied by wing flapping—and mobbing—when multiple crows scorn together. In the study, a person was given a human mask to wear and would then perform an aversive behavior toward a crow: catching, banding, and releasing. While this action doesn't harm or cause pain to the crow, they would rather avoid it. Over a period of five years, a person would then walk a route on which the crows were caught and wear either the dangerous mask (the one that was worn during bird handling) or a neutral mask (a mask the crows hadn't seen before).

What the authors found is that crows would scorn the dangerous mask worn during capture and over the five year period following the single capture event, the number of crows that would scorn the dangerous mask increased and larger mobs would form. What this tells us is that not only are crows able to learn and recognize human faces—which is impressive enough because we really don't all look that different (sorry)—the crows were able to learn and associate a person with a behavior. Crows worked together to scorn a person which is a protective behavior but also serves as teaching. Crows would learn threatening people secondhand; they could learn a person is a threat not through personal experience, but from a fellow crow. Crows display social intelligence which is important for survival, and they were able to learn a person after a single encounter. This is called one-trial learning and has been shown to be extremely beneficial[5].

# Scrub Jays

Scrub jays are what are known as caching birds. This means that they hide and store food for future use. Scrub jays are able to remember details about their caches such as what type of food they stored, if it will decay, where it is, and even if another bird was watching and might steal it. Scrub jays are able to retain this information for thousands or possibly tens of thousands of caches over a range of roughly thirty miles.

Blue Jay by Susan Young. 2018. Flickr.

## Planning for the future (without a calendar)

Planning for the future is a complex task which requires the manipulation of knowledge you know into assumptions about what hasn't happened (but is assumed will). Many scientists theorize that this is such a complex task that animals other than humans can't master it. But if only humans could master it, how do you explain wolves making dens or the behavior of birds hiding before they die? A 2007 study by Raby, Alexis, Dickinson, and Clayton, showed that scrub jays are able to plan for the future in a simple breakfast experiment.

The experiment consisted of a three conjoined cages. The center cage was a neutral cage, in the left cage (what we will call the hungry side), the bird was taught over time that it would not receive food. In the right cage (what we will call the breakfast side), the bird was taught that it would be given food. A scrub jay would sleep in the center chamber then in the morning randomly be given access to the hungry side or the breakfast side. The scrub jay was able to learn pretty quickly that only the breakfast side is where they'd be given food. What happened next is what shows scrub jays can plan for the future.

Once the scrub jays learned where they would and wouldn't be given food, they were given access to all cages and food. In the bottom of each cage was a caching tray (an ice cube tray full of sand or soil). The scrub jays would cache much more food in the hungry cage. This indicates that the scrub jays know they won't be given food in the hungry cage, so they must supply their own[6]. The scrub jay understands that it will be hungry and in order to eat in the morning, he better brown bag it.

## Is this wax worm still good?

Scrub jays cache various types of food including nuts, berries, and worms. If you've left a banana in your bag by mistake versus the well-intentioned bag of trail mix at your desk, you know that fruit goes bad much more quickly than nuts. As it turns out, scrub jays know this, too. Clayton and Dickinson, a decade before the above study, found in 1998 that scrub jays understand the concept of food decaying in their caches.

How they did this was by giving scrub jays the opportunity to cache both nuts (which scrub jays like) and wax worms (which scrub jays LOVE) then gave the jays either 4 or 124 hours to get hungry before allowing them to return to their caches. What they observed is that after the 4 hour delay (when the wax worms would still be good), the scrub jays returned to caches of wax worms significantly more frequently. In contrast, after the 124 hour delay (when the wax worms would no longer be edible), the scrub jays would return to the caches of nuts significantly more frequently[7].

From this we can glean that the scrub jays understand both the passage of time and what that means for the freshness of the food they've cached. They apply this information to their memory of what food they stored where and make their choice accordingly.

# Pigeons

Ah the city-dweller's friend, cleaning up the dropped fries, falafel, and other street food and nesting in office buildings. Pigeons might be seen as a nuisance (and well, they are), but they are often viewed as a stupid nuisance. I'm here to defend pigeons as more intelligent than we give them credit for.

Pigeons, and especially homing pigeons, are commonly used in research. Homing pigeons are domesticated rock doves and are much like their wild counterparts, except they have been bred to be more motivated to return home. This is useful when using pigeons to send messages or in research to study how pigeons navigate[8].

## I sort-a know what this is

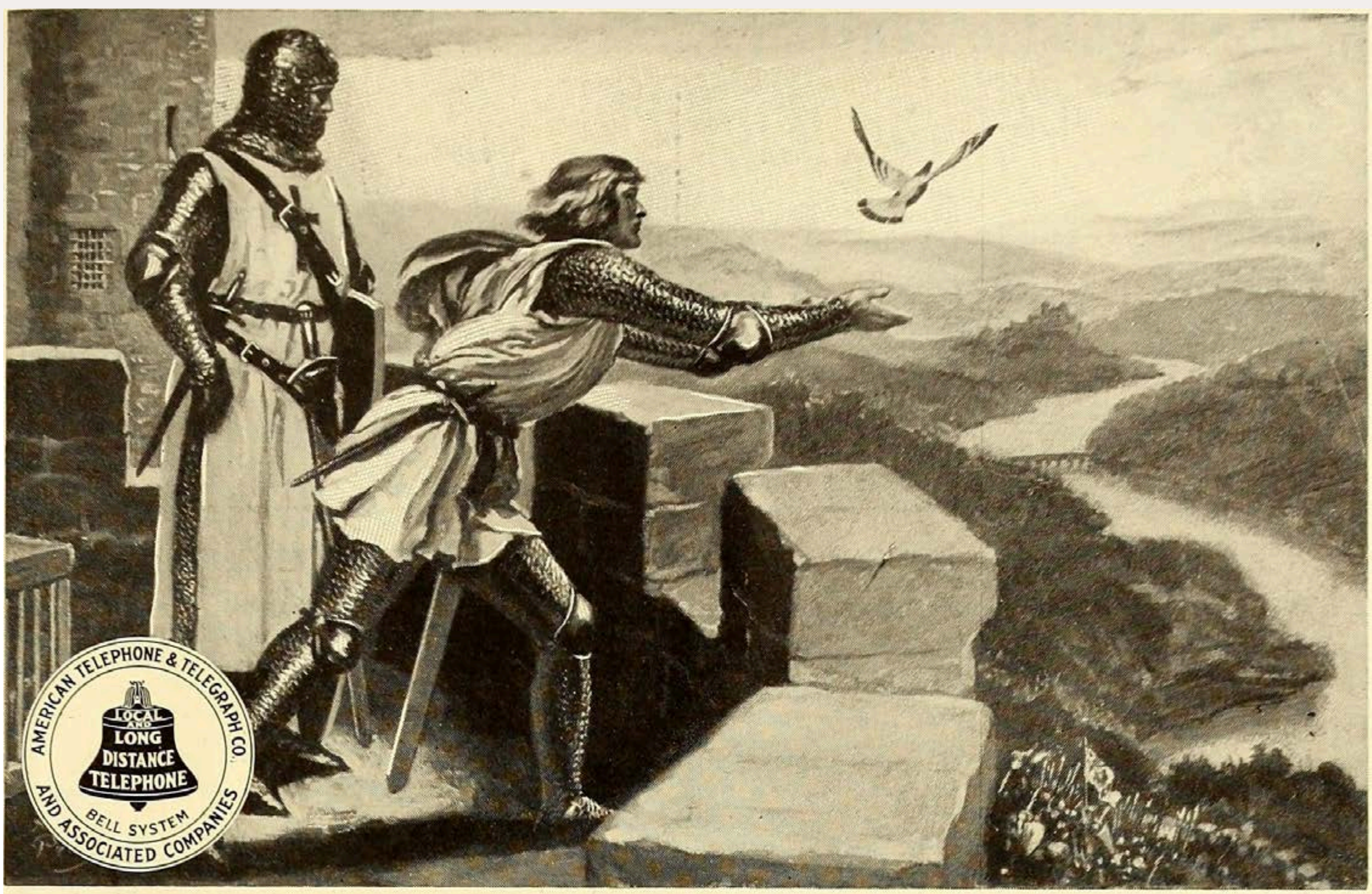
Not only are pigeons able to find their way home, but they can identify objects and create schemas or categories that they can apply to novel images. Wasserman in 1995 tested this by teaching a pigeon to choose one of two images presented on screens by pecking at it. The pigeon was then presented with an image and tasked with pecking the image that was in the same category. If it did so correctly, it was rewarded. Since there is no way to explain to a pigeon what the categories are, the pigeon learned by trial and error. Once categories were established with one set of symbols, new symbols were introduced. The pigeons were able to categorize the new symbols according to previously learned categories 65% of the time—which is impressive enough let alone when you consider the pigeon is flying by the seat of its pants (or tail feathers) with no context[9].

## The boy scouts of the sky

Homing pigeons have an incredible ability to figure out where they are and how to get to their destination. There are multiple theories of how pigeons do this, one theory being the "map and compass" model. The map part is that pigeons will establish where they are in space in relation to where they want to be. But rather than a topographical map we might be used to, a pigeon's map is created using an olfactory "mosaic". Winds carry different smells toward their home and around familiar terrain that pigeons use to create a distribution of smells. Then, when they navigate, they use ambient odors to orient themselves. Pigeons will combine this olfactory map with visual cues if they are in

*From page 98 of "Lilliput Lyrics ... Edited by R. Brimley Johnson. Illustrated by Chas. Robinson" by William Birghty Rands. 1899. flickr.*

a well-known environment. So now that they have a map, they need the "compass" part. Pigeons will establish and then follow a direction toward their goal. Their main compass is the sun, but pigeons also use magnetic fields. Birds are




*From "American Homes and Gardens" page 258, 1905* able to sense magnetic fields in part due to the help of a protein in the retina called a cryptochrome, and specifically cryptochrome 4. Cryptochromes are light-sensitive proteins that help regulate the circadian clock and are significant in magnetic detection. Levels of most cryptochromes fluctuate at different times of day due to light exposure, with the exception of cryptochrome 4. Cryptochrome 4 will change shape in response to light, and its levels are constant throughout the day, which would be beneficial for a navigation detector that is frequently used[10].

Pigeons are able to apply their map even to unknown territories, as demonstrated in 2013 in a study by Blaser, Dell'Omo, Dell'Ariccia, Wolfer, and Lipp. In the study, pigeons were taught a path between a home loft and a feeding loft. Once the pigeons learned the two locations, they were driven to an unfamiliar territory with no visual or olfactory cues along the way. Once at the release location, half of the pigeons were fed and half were left hungry to see if motivation impacted to which location the pigeons flew. The pigeons were able to successfully find their way back to the lofts, and it was seen that the hungry birds flew to the feeding loft and the fed birds flew to the home loft[11].

When navigating, pigeons will also fly better in a flock. The flock is led by the pigeon with the most experience and the one who is a good leader. If the flock thinks the leader isn't being effective, then who the leader is will change. But the impressive thing about a flock of pigeons is they can navigate routes none of them has flown before to get to the same destination. Pigeons can work together to combine their maps to arrive at the destination. Flying in a flock allows pigeons to learn new routes and areas from others[8].

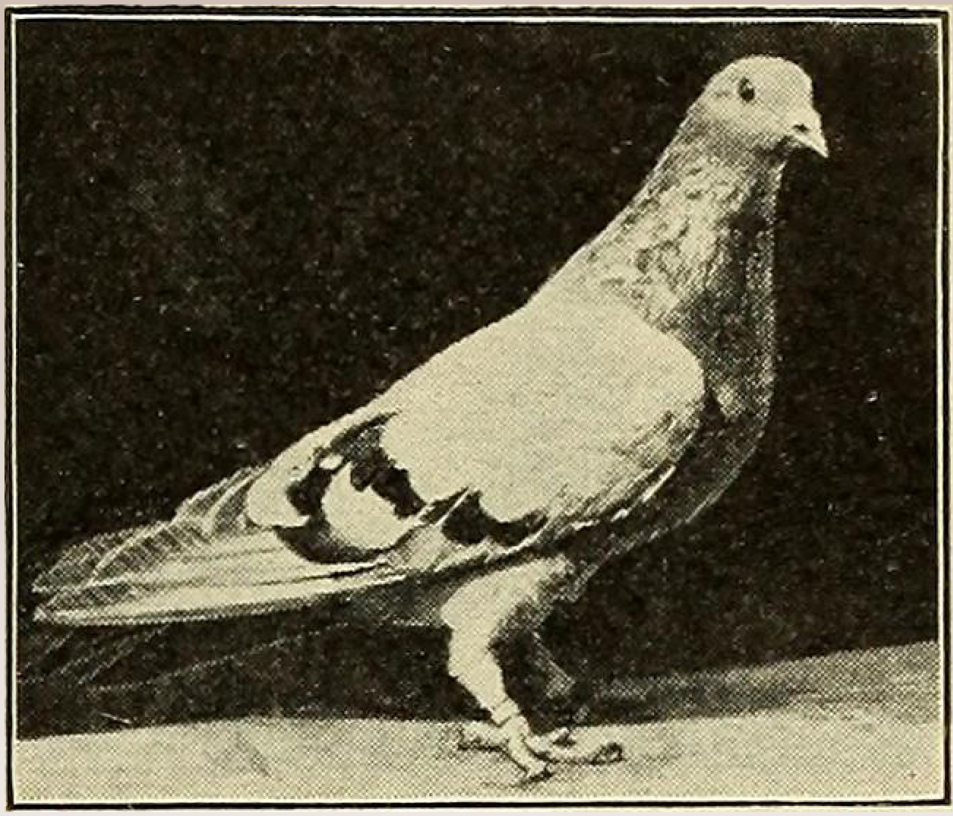


*Image by John Henry Robinson from "Our Domestic Birds". 1913. flickr*

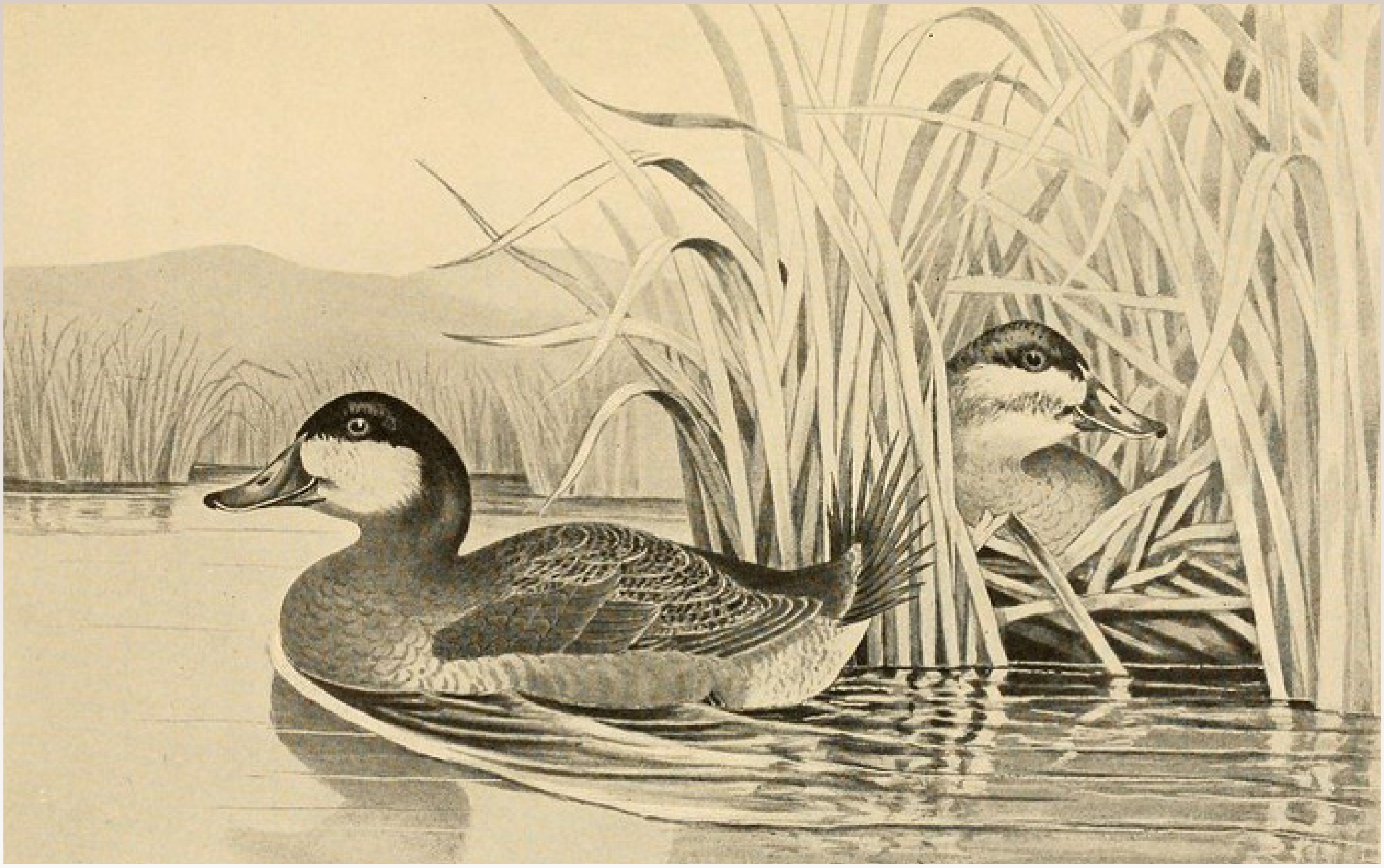
## So birds are smart, but are we smart enough to understand just how smart they are?

Not really. We only know intelligence from our point of view. We're operating under the assumption that animal cognition, intelligence, and logic would work like ours does. And by extension, we are making the assumption that parts of the brain that appear to be analogous do have the same function. There is actually evidence that this might be so, and for this we turn to song birds.

A walk through the woods in the spring or summer often is accompanied by the tweets of birds. Song birds are capable of complex vocal sounds and also vocal learning—skills also used by humans. Though we both evolved these skills independently, when looking at the brains of song birds and humans, similar neural pathways begin to emerge. In humans, Broca's area and Wernicke's area are highly used in vocal learning and language production, they are often called the "language centers" of the brain. As it turns out, song birds have structures that look and seem to function much like the human Broca's and Wernicke's areas[2]. This might suggest that, though evolved independently, analogous structures might exist in different taxons.

But when it comes to wondering if animals have intelligence or might use cognition like we do, we can't ask them yet, so we don't know. How do we study something that is beyond us? We apply the tools we have such as behavioral tests and brain scanning, but any knowledge we gain is built on the assumption that all brains end up working the same to some degree. When we look at human brains we see a huge variance in what they do and how they think. Can we then make the assumption that an intelligent brain that evolved independently of hominid brains would produce the same logic? Maybe, maybe not. There are cases of the same trait evolving independently, for example, both bats and whales using echolocation and humans and koalas both having fingerprints. What if intelligence is another example? Perhaps one day we will be able to answer these questions.

Just be careful because next time you call someone a birdbrain—it might just be a compliment.



*"n610_w1150" by BioDivLibrary from CC*

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