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Tool Use in Corvids

Tool use is often considered a skill that is indicative of higher levels of cognition in non-human animals. Research and experiments related to tool use are often performed on animals that we deem intelligent enough to be able to grasp this skill. What is remarkable about the ability of animals in the corvid family to use tools is that their brain size is many times smaller than those of primates, cetaceans, or other stereotypically intelligent animals, yet their cognitive abilities in many contexts appear to be on par with other highly intelligent animals. This paper will focus on research related to tool use in corvids and will explore the problem solving capabilities and strategies that research has revealed, as well as discuss the comparisons between primate and corvid cognitive abilities when faced with these types of situations.

For any animal species, one of the most fundamental aspects of tool use is the selection of the appropriate tool. New Caledonian crows, *Corvus moneduloides*, display frequent tool manufacture and use both in the wild and in captivity. One group of researchers observed wild New Caledonian crows to try to determine what strategy they would use in response to a tool-length task (Hunt et al., 2006). Logs with holes of various depths were set up and meat and larvae were hidden inside the holes (Hunt et al., 2006). Hunt and his team observed that the crows always seemed to use a default length of tool for their first try in extracting the food. They did not seem to assess the depth of the hole before making their first tool and would make a second longer tool if the first was inadequate (Hunt et al., 2006). The tools that were made after the first were usually longer than the first. This suggests that the behavior was not a result of trial-and-error strategies, since the second tools were consistently longer, rather than of random lengths (Hunt et al., 2006). The results of this study suggest that New Caledonian crows approach familiar problems using a practiced, default behavior and modify it if their first attempt fails.

Another important aspect of tool use in humans is the use of tools and objects on non-food related items. Although tool use in avian species is regularly studied and reported on, it has only been observed in food-related problems (Wimpenny, Weir, et al., 2011). Wimpenny and her team conducted a study to investigate whether New Caledonian crows will use tools in a non-food related context. The group conducted their study on both wild-caught subjects and hand-raised subjects. They removed all items except twigs, leaves, and other possible tools from the crows' aviary and placed an assortment of novel objects around the ground (Wimpenny, Weir, et al., 2011). Any possible tool items were pushed to the sides of the aviary so that the crows would have to go out of their way to fetch the tools if they wanted to use them (Wimpenny, Weir, et al., 2011). The novel objects did not contain any holes, folds, or crevices that could potentially contain food (Wimpenny, Weir, et al., 2011). Out of seven wild-caught subjects, three of them used tools to make first contact with a novel object (Wimpenny, Weir, et al., 2011). Out of three hand-raised birds, only one of them used tools to make initial contact (Wimpenny, Weir, et al., 2011). This suggests that they may have been less hesitant to make direct contact with novel objects due to their familiarity with humans (Wimpenny, Weir, et al., 2011). However, the sample size of this group was very small compared with the group of wild-caught crows. A larger group of hand-raised subjects would be able to provide more reliable evidence for this theory. The team also noticed that the crows were usually cautious when approaching the objects and often retreated quickly after making initial contact with a novel object(Wimpenny, Weir, et al., 2011). One explanation for this behavior is that novel objects may either be a potential food source or a threat, so investigating them from a safe distance through the use of a tool object reduces the risk factor for the crows. The results of the study suggest that the crows may be aware of this, but I believe that further research on a greater number of subjects is needed to fully test this theory.

Researchers Christopher Bird and Nathan Emery conducted a study to determine whether rooks, *Corvus frugilegus* of the Corvidae family, would be able to learn tool-use skills, a behavior that has not been observed in rooks in the wild (Bird & Emery, 2009). The team modeled their experiment on Aesop's fable, presenting the rooks with a tube of water containing a floating worm and a pile of stones in the vicinity (Bird & Emery, 2009). Bird and Emery set up three different experiments to test different aspects of the task. To successfully obtain the worm in the first experiment, the rook must drop stones into the tube, displacing enough water to raise the worm to a reachable height. The height of the water varied between trials and in each trial, the rooks put in only the number of stones necessary to raise the water level to a reachable height (Bird & Emery, 2009). The rooks appeared to assess the water level before each trial to estimate the number of stones that would be needed, this suggesting that their behavior was goal-oriented (Bird & Emery, 2009). In the second experiment, rooks were given stones of a variety of sizes (Bird & Emery, 2009). They learned over time to that using the larger stones was more efficient than using the smaller stones (Bird & Emery, 2009). This presents two possible developments in the rooks. They either learned that the physical properties of the stones and water resulted in the displacement of more water, or they simply observed that the water level rose faster when they used larger stones, allowing them to obtain their reward more quickly (Bird & Emery, 2009). Either way, they were able to learn that using larger stones allowed them to solve the task most efficiently. In the third experiment, the crows were given two tubes: one filled with water and the other with sawdust. The sawdust was a novel medium to them and they quickly learned that sawdust cannot be manipulated in the same manner as water (Bird & Emery, 2009). They initially showed a preference for water in their first trial, but this was reversed by the second trial (Bird & Emery, 2009). This indicates that they did not have an innate understanding that sawdust does not behave like water, but they had the ability to learn and adapt to this new situation. The birds that had prior experience with the other trials learned more quickly to avoid the tube with the sawdust, while the bird who was given this setup as his first experimental trial took slightly longer, which suggests that the speed of their learning is facilitated by previous experiences (Bird & Emery, 2009).

The results of Bird and Emery's research indicate that not only are rooks capable of solving this task, but that they are also aware of details such as changes in water level and are able to plan accordingly, adjusting the number of stones that they drop into the tube. This experiment also provides evidence for flexible tool use skills in this species, which has not been observed to use tools in the wild, suggesting that the cognitive solutions to physical tasks in this species originate from a general understanding of physical rules rather than specialized tool-use adaptations (Bird & Emery, 2009). This raises the question of why they don't use tools in the wild, similarly to capuchin monkeys, which often use tools in laboratory settings, but scarcely use them in the wild (Bird & Emery, 2009). I speculate that perhaps tool use is simply unnecessary for these animals in their natural habitats, where food may be so abundant and easily obtained that there is no reason for them to exhibit tool-use behaviors.

Many researchers consider the next step in tool-using animals to be meta-tool – or sequential – tool use, which is the use of a tool on a non-food object in order to later obtain a food object. Using tools on non-food objects is considered a hallmark of human intelligence and is associated with the ability to plan ahead and act on the basis of reasoning, rather than instinct (Taylor et al., 2007). There are three distinct cognitive requirements for meta-tool use: the ability to recognize that tools can be used on non-food objects, the ability to control and inhibit the initial reflex to obtain the food object – a task difficult for most primates and children, and lastly the capacity for hierarchical organization, which allows for the identification of a tool-on-tool action to be a sub-goal towards the main goal of obtaining food (Taylor et al., 2007). Meta-tool use is considered to be indicative of analogical reasoning, with the analogy being the translation of food retrieval using a tool to tool retrieval using another tool (Wimpenny et al. 2009). It is believed that the greater number of tools required in the sequence, the more challenging the overall task is to complete (Wimpenny et al. 2009). There are a few reasons for this, including that initiation of the sequence is further from the goal, which would require greater abstraction of the overall task (Wimpenny et al. 2009). Additionally, the probably of generating a correct sequence of three or more actions at random is less probably than that of only two actions (Wimpenny et al. 2009).

Tests for meta-tool use in primates usually involve presenting the subject with a food item that is out of reach without the use of a long stick tool (Taylor et al., 2007). The necessary tool is placed out of their reach, but they are provided with a shorter stick tool that would allow them to reach the longer tool (Taylor et al., 2007). In order to succeed in this task, the subject must use the shorter tool to obtain the longer tool, which can then be used to obtain the food. Chimpanzees and other apes are able to solve this task, but monkeys usually cannot (Taylor et al., 2007).

One study related to meta-tool use in corvids was conducted by Alex Taylor and his team on seven wild-caught New Caledonian crows. They modeled their experimental design on the meta-tool experiments usually performed on primate subjects (Taylor et al., 2007). The group set up two wooden tool boxes, which had vertical bars in the front, allowing the crows to see the objects inside, but not allowing them to reach the objects (Taylor et al., 2007). A short distance away, food was placed in a clear horizontal container which would allow the crows to extract the food using a long stick tool (Taylor et al., 2007). One toolbox contained a long stick tool and the other contained a stone (Taylor et al., 2007). A shorter stick tool was placed outside the toolboxes, which could be used to obtain the longer stick, but not the food (Taylor et al., 2007). The crows were given several familiarization trials with the apparatus, including extracting food from the hole and obtaining the long tool which was placed so it was protruding from the toolbox (Taylor et al., 2007).

All seven crows tested in this experiment developed meta-tool use and were able to extract the food (Taylor et al., 2007). Three crows produced the correct behavioral sequence in their first trial and a fourth was able to extract the food after an initial failed attempt to pull out the longer tool (Taylor et al., 2007). Significantly, the first use of the shorter stick by six of the seven crows was either successful meta-tool use or a failed attempt to extract the long tool (Taylor et al., 2007). The results of this study provided experimental evidence that New Caledonian crows are capable of spontaneously solving a meta-tool task. The behavior of the crows was not indicative of trail-and-error learning, since they did not seem to be randomly probing the different boxes and never tried to extract the stone (Taylor et al., 2007). It is also unlikely that this was a previously learned behavior for the crows, since familiarization training with the crows did not involve meta-tool use and this behavior has never been observed in the wild (Taylor et al., 2007). These findings suggest the possibility that the crows solved the meta-tool task through analogical reasoning, in which they solved the talk by perceiving the shared relationship between obtaining a food object with a tool and obtaining a non-food object with a tool (Taylor et al., 2007). I personally believe that the familiarization trials may have made the solution to the task too apparent for the crows, since they performed almost every action necessary in those trials. Additionally, they were never required to use the stone as a tool in those trials, which may have contributed to the reason that it was never extracted from the toolbox.

Another group of researchers interested in this topic shared some of the same concerns about the familiarization trials in Taylor's study and conducted a follow-up study with a different experimental setup (Wimpenny et al. 2009). The group used clear acrylic tubes containing different sized stick tools that could be used to obtain food that was in its own acrylic tube (Wimpenny et al. 2009). They used two groups of three crows. One group was familiarized with retrieving tools from tubes with their beaks and using the tools to retrieve food, while the other was not (Wimpenny et al. 2009). All three subjects experienced with the tubes showed sequential tool use on their first experimental trails and consistently afterwards, although they did not always extract the correct length of tool on their first try (Wimpenny et al. 2009). The three subjects inexperienced with the task never retrieved the tool when more than one tool was required (Wimpenny et al. 2009). However, after allowing them more trial blocks, one crow was able to improve dramatically and consistently performed better after figuring out the correct strategy (Wimpenny et al. 2009). Another crow in the group never used one tool to retrieve another, although it appeared that this could have been due to lack of attention or an aversion to the tool tubes (Wimpenny et al. 2009).This provides evidence that even corvids with no prior experience or training related to meta-tool use are able to spontaneously produce this behavior, as well as remember and apply it in later situations.

Wimpenny's group determined that their first experimental design may have been flawed. They suspected that the shape and reflective material of the tubes may have obscured their contents from the birds, since they were unable to see through the acrylic from the sides and had nowhere to perch to view it from above (Wimpenny et al. 2009). The second experiment replaced the tubes with wire-mesh frames, which would allow subjects to stand on them and view food and tools directly from above, or from the side (Wimpenny et al. 2009). Three subjects were tested in this experiment and all three were familiarized with the frames to ensure that there was no aversion to them (Wimpenny et al. 2009). During the familiarization period, food and non-tool objects were placed inside the frames (Wimpenny et al. 2009). During the experimentation period, all three subjects probed for tools on their first trial and consistently afterwards (Wimpenny et al. 2009). All were able to obtain the food in each trial, but their efficiency decreased as the task complexity increased, requiring them to use more tools, although all three subjects were able to solve the three-tool problem (Wimpenny et al. 2009). The team noted that the further the food as placed into the frame, the greater the probability that the subjects would first probe for a longer tool. These observations suggest that the crows were sensitive to the position of the food when deciding whether to probe for food or for tools.

Overall, Taylor's and Wimpenny's studies provided strong evidence that New Caledonian crows are capable of meta-tool use. The researchers observed that the crows' efficiency in these tasks improved with experience and that they showed flexibility in their behavior (Wimpenny et al. 2009). The crows limited their probing in the food frame when food was absent and when tools were unnecessary, they did not extract them as often (Wimpenny et al. 2009). Wimpenny's research reinforces the theory that when faced with these types of tasks, crows are capable of planning their actions, rather than simply making associations based on repeated experience, since they were able to succeed in Wimpenny's second experiment without previous tool use introduction (Wimpenny et al. 2009).

These studies provide solid evidence for exceptional tool use and problem solving skills in corvids. It has been shown that corvids are capable of selecting the appropriate tool for a specific situation, flexibly modifying their behavior in accordance with the problem they face, using tools for exploratory non-foraging purposes, and solve more complex problems requiring multiple tools. Additionally, the behavior that was observed in these experiments suggests that corvids are capable of analogical reasoning and have cognitive abilities comparable to those of non-human primates.

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