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Abilities of Birds

Kevin Brewer

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Orsett Psychological Services
PO Box 179
Grays
Essex
RM16 3EW
UK

orsettpsychologicalservices@phonecoop.coop

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Kevin Brewer BSocSc, MSc

An independent academic psychologist, based in England, who has written extensively on different areas of psychology with an emphasis on the critical stance towards traditional ideas.

A complete listing of his writings at <http://kmbpsychology.jottit.com>.

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1. CLEVER CHICKENS

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1.1. INTRODUCTION

Studies are showing that particularly species of birds have complex cognitive abilities ¹, like tool use (New Caledonian crow), or numerical abilities (African grey parrot) (Smith and Zielinski 2014). An overlooked intelligent bird is the chicken (*Gallus gallus domesticus*) ² (which is a sub-species of the Red Junglefowl).

Knowledge about the chicken has developed slowly over the last century. For example, in the 1920s, Thorleif Schjelderup-Ebbe coined the term "pecking order" to describe the chicken's dominance hierarchy (Smith and Zielinski 2014).

Here are three areas of cognitive ability that recent research has highlighted.

1.2. SOPHISTICATED COMMUNICATION

Based on recordings at San Diego Zoo, California, USA, Collias (1987) established that chickens have twenty-four different sounds which are related to specific events/objects (eg: brief, low frequency calls are attraction, and loud, high frequencies are alarm calls) ³. For example, chicks have five different calls, and there are different alarm calls for aerial and ground predators.

Evans and Evans (1999), for example, played a particular call to a chicken and the hearer/receiver behaved as the caller (table 1.1). This means that each call is "functionally referential" (ie: a signal that

¹ This is different to senses or abilities that humans do not have. These can appear impressive, but may be innate as in magnetic sense (appendix 1A).

² This has "ethical implications for how society treats farmed chickens: recognising that chickens have these cognitive traits compels moral consideration of the conditions they endure as a result of production systems designed to make chicken meat and eggs as widely available and cheap as possible" (Smith and Zielinski 2014 p48).

³ Calls can also be part of vocal duets (appendix 1B).

evokes a specific response in the receiver without contextual cues; Smith and Evans 2009)^{4 5}. So, hearing a call for a ground predator (eg: fox) produces a behaviour in the hearer as if they had seen the fox themselves.

- Male chickens produce food calls and a visual display when food is found (tidbitting)⁶, and so it is not clear if the call has specific meaning or whether the hearer is responding to the visual signals or seeing the food for themselves. Playback experiments allow researchers to isolate the call, as done by Evans and Evans (1999).
- They played recordings of male food calls or ground predator alarm calls to twenty-two hens⁷ who were individually placed in a quiet chamber. The hens' response to the calls were categorised from video recordings by blind judges (ie: individuals who did not know which call had been played) into behaviours like inspects floor/looking downwards (response to food call), and moves towards caller and/or calls back (social response).
- Looking downwards during and after the calls happened significantly more often with the food calls than the alarm calls. Alarm calls and food calls are similar in acoustic characteristics, but the hearers could distinguish them, and the food calls carried specific meaning. This is evidence that food calls are functionally referential.
- Generally, in response to ground predator alarm calls, hearers scan the horizon, while they look upwards in response to aerial predator alarm calls.

Table 1.1 - Evans and Evans (1999).

Giving an alarm call helps others nearby (eg: mates and kin), but puts the caller at risk from the predator (ie: increased likelihood of detection). Thus calling may be selective ("appropriate audience" - eg: only when kin at risk) (Kokolakis et al 2010). For example, Wilson and Evans (2008) found that roosters increased their aerial predator alarm calls when mating opportunities were

⁴ The alternative is that calls are "behavioural referents", where the calls are made in social groups only, and convey information about the sender's social status (Evans and Evans 1999). In the case of functionally referential, a food call is made when food is found (even if the individual is alone), say, but only in the presence of others if behaviourally referential. For example, ravens only produce "yells" when a certain number of birds are present (Evans and Evans 1999).

⁵ The visual component is also functionally referential. Smith and Evans (2009) showed hens videos of males performing food found behaviour (tidbitting) without sound or with sound playing backwards. The researchers also had a male crowing without sound or inactive, and an empty cage as controls. The hens responded with food searching behaviour significantly more to the silent tidbitting than any other condition. "Tidbitting movements, therefore have all the characteristics of a functionally referential visual signal. When combined with food calling, as in the majority of displays, this constitutes the first experimental demonstration of multimodal referential signalling in a non-human vertebrate" (Smith and Evans 2009 p841).

⁶ Hens prefer to mate with males who provide food (Pizzari 2003).

⁷ Adult golden Sebright batam hens at Macquarie University, Australia.

experimentally increased (ie: more potential or actual mates in the vicinity).

Kokolakis et al (2010) showed this behaviour in naturalistic observations of twenty-four male and twenty-four female golden Sebright bantams in outdoor aviaries at Macquarie University. The observations, using video cameras, and microphones attached to the birds, took place during the breeding season. Dominant males had significantly higher mating success and produced significantly higher average number of aerial alarm calls than subordinate males. This fitted with the idea that the caller takes a calculated risk (or makes a "judicious investment") - makes themselves conspicuous to predator (cost) versus warns females previously mated with (benefits).

That calling can be adapted to the audience suggests an understanding of others. For example, a male safe under a bush gives the alarm call when there is an aerial predator if his rival is in the open. The sound will attract the predator to the rival in the open rather than to himself (Smith and Zielinski 2014).

1.3. BEHAVIOURAL FLEXIBILITY

Researchers have designed a "Chicken Big Brother" (Smith and Zielinski 2014) to study behaviour. This involves placing microphones and cameras around the outdoor aviaries at Macquarie University, Sydney, Australia. Then in "Chicken Big Brother 2.0" (Smith and Zielinski 2014), wireless microphones were placed on the chickens in lightweight backpacks.

This level of behaviour showed secretive behaviour by the subordinate male. Because of the pecking order, these individuals are harassed by the alpha male if they step out of line (eg: try to attract female). When an alpha male finds food, he shows a behaviour called "tidbitting"⁸ and calls to attract females. Any subordinate male doing this behaviour in the presence of hens is attacked by the alpha rooster, who claims the food and then makes the food calls (Stokes and Williams 1972). But it was found that the subordinates performed the tidbitting without the call (ie: "subordinate silent tidbitting") (Smith and Evans 2008). This attracted the females without alerting the alpha rooster. It is evidence of behavioural flexibility.

⁸ Tidbitting can be described as involving three elements (Smith and Evans 2009) - twitch (side to side movement of the head), short bob (bending forward towards the food, but stopping halfway), and long bob (bending forward and picking up food).

1.4. EMPATHY/TAKING ANOTHER'S PERSPECTIVE ⁹

Edgar et al (2011) gave chicks a harmless 30-second puff of air that ruffled the feathers, but caused a stress reaction in the chicks. Observing mothers showed a similar stress reaction, and they increased their calls to the offspring. The measures of behavioural and physiological arousal in the hens included increased alertness, raised heart rate, less preening, and lowered eye temperature.

These responses could be purely in reaction to the chicks' calls or behaviour (ie: automatic), or because of the ability to take the chicks' perspective. Prospective-taking is a more sophisticated cognitive ability.

Edgar et al (2013) found the latter to be the case. Twelve hens and their brood of chicks in the UK were trained to associate yellow with "safe" and red with "danger" (an air puff). During testing, a hen observed one of her chicks placed in a coloured box based on six conditions:

1. Same/safe - Hen sees chick placed in yellow box (ie: no danger).
2. Same/danger - Hen sees chick placed in red box (ie: danger).
3. Different/safe - Hen sees chick placed in yellow box, but it is really red box (ie: danger for chick, but hen expects no danger).
4. Different/danger - Hen sees chick placed in red box, but it is really yellow box (ie: hen perceives danger, but none for chick).
5. Unconditioned/safe - Hen sees chick placed in yellow box before birds have been trained (ie: control for condition 1).
6. Unconditioned/danger - Control for condition 2.

The hens were monitored for signs of arousal. The key conditions of the experiment were numbers 3 and 4, where the hens are led to believe the opposite to what will happen. So, in condition 4, the hens will be aroused because of their own knowledge and not the chicks' distress if the hens are perspective-taking. Edgar et al (2013) concluded: "The mother hens' behavioural changes observed in the current study were dependent upon their

⁹ "Emotional empathy occurs when one individual (the observer) detects the emotional responses of another individual (the demonstrator), in response to a stimulus, triggering a matching emotional response in the observer" (Edgar et al 2013 p223).

own perceptions of chick 'danger' and 'safety', regardless of the chicks' perceptions. This indicates that the hens' behaviour was driven by their own knowledge of the situation, rather than a direct response to distress-related behaviour in the chicks" (pp228-229).

1.5. APPENDIX 1A - MAGNETIC SENSE

In the 1960s it was first shown experimentally that birds navigate using the Earth's magnetic field. The direction that birds head can be changed by powerful magnets (Yong 2010).

But how do birds sense magnetism? One answer is magnetoreceptors (structures rich in iron in the beak, say) (eg: Falkenberg et al 2010).

Another possibility is cryptochromes. These are proteins found in plants and animals which detect blue light, and are disrupted by high-frequency magnetic fields (eg: Ritz et al 2000). This would mean that the magnetic compass of birds is located in the eyes (probably the right one) (Yong 2010).

Thus the magnetic fields appear as areas of light and shade on top of the normal visual field. Placing frosted goggles on the right eyes of robins, for example, has been found to disorientate them (eg: Stapput et al 2008).

1.6. APPENDIX 1B - VOCAL DUETS

Vocal duets are where one bird's song is overlapped by another's (usually a mate). The function seems to relate to mate guarding, avoiding misdirected aggression from mate, and joint resource defence¹⁰ (Koloff and Mennill 2013).

Koloff and Mennill (2013) reported on the duets of Barred Antshrikes (*Thamnophilus doliatus*) (figure 1.1) in part of Costa Rica. A duet was defined as "one bird's song temporally overlapped at least some portion of the mate's song". Male-created duets were when the male overlapped the already singing female, and vice versa for female-created ones. Solo songs had no overlapping. The songs of 76 birds in thirty-eight territories were recorded over seven months in 2009 and 2010.

Solo songs varied between males and females in pitch and duration, for example. Most duets were female-created (84%). It has been suggested that this is a female mate-guarding strategy. Koloff and Mennill (2011) found that females were most aggressive in response to female solo

¹⁰ For example, Fedy and Stutchbury (2005) found greater aggression towards playback of a stranger's call among White-bellied Antbirds during the dry season (when food is scarce) than in the rainy season (when food is plentiful).

songs in a playback experiment, while both sexes responded aggressively to recordings of duets.

Duets were observed by Koloff and Mennill (2013) as responses to neighbouring birds duetting as a territory signal, or as the pair of birds moved around their territory, but not while the female was incubating.



(Source: 3headeddog/Charlie Westerinen)

Figure 1.1 - Female Barred Antshrike.

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2. HUMAN FACIAL RECOGNITION BY CROWS

- 2.1. Introduction
- 2.2. Marzluff et al (2010)
- 2.3. Appendix 2A - Bogale et al (2011)
- 2.4. References

2.1. INTRODUCTION

The ability to recognise individual members of the own species is beneficial to know who is "friend or foe", for instance, but few species can recognise individuals of other species. The exceptions are domesticated species and those who have contact with humans, say.

For example, birds that live in urban areas can recognise individuals who feed them or who harass them ¹¹. Marzluff et al (2010) showed this ability in experiments with wild American crows (*Corvus brachyrhynchos*) (figure 2.1) in Seattle, USA.



(Source: mdf)

Figure 2.1 - American crow.

¹¹ A "learned adaptation to life in the big city" (Black 2013). This ability could suggest a mutual co-evolution of the two groups (Marzluff and Angell 2005).

2.2. MARZLUFF ET AL (2010)

In their first experiment, two researchers who were trapping the birds to tag them did so while wearing a "caveman" mask ("dangerous mask") and straw hat. After release, the reaction of the crows to the researchers was observed as they walked around the area where the crows were based. The crows made significantly more scolding vocalisations towards individuals wearing the mask and hat, the mask only, the hat only, or the mask upside down than to individuals with no mask or a neutral mask. This behaviour was observed up to three years after the trapping experience.

In the second experiment, birds at other sites were trapped by researchers wearing particular masks and red armbands. Subsequently, the crows produced scolding vocalisations to these masks, irrelevant of the physical build of the individual wearing them. The presence or absence of the armband produced no difference in scolding responses.

The previous two experiments had observed the birds reaction to a single person walking near them. In experiment three, two individuals approached the crows from different directions, one wearing the "dangerous mask" and the other a neutral one. The crows produced the scolding vocalisation and followed the individual in the "dangerous mask", while ignoring the individual in the neutral mask.

Marzluff et al (2010) had shown "rapid learning to a brief, single experience, long-term memory retention, and fine-feature discrimination between individuals of a different species in wild free-ranging birds" (p704) ¹².

Technically, the birds in these experiments were recognising the masks rather than individual humans or their faces. But Clucas et al (2013) showed that American crows could distinguish human gaze direction (and not facial expressions).

The same areas of Seattle where crows congregate were used in these experiments. In the first experiment, an individual researcher walked towards a crow either staring at the bird or looking away. An observer estimated how close the human got before the bird flew away (flight initiation distance; FID) using a laser rangefinder. For the 24 approaches with direct gaze, the birds flew away sooner than the twenty-three approaches with averted gaze (average = 3.2 m difference). In other words, the researchers got closer to the bird when they

¹² Marzluff et al (2012) showed similar brain regions were active in humans and crows in facial recognition. Twelve male crows were captured by researchers wearing a particular mask ("threatening mask"), but fed during captivity by individuals wearing another type of mask ("caring mask"). During PET scanning, the crows were shown images of the two masks and an empty room (control).

were looking away.

In the second experiment, the researchers also varied the facial expression (smiling or scowling) with the gaze to give four conditions - direct gaze/smiling, direct gaze/scowling, averted gaze/smiling, and averted gaze/scowling. The facial expression had no effect on FID, only the gaze again.

The findings showed that "crows may interpret direct eye contact from an approaching human as a potentially threatening situation or simply that they are the focus of the human's attention. As a species living in human-dominated environments, this awareness allows crows to devote more time to foraging and other activities while in close proximity to people passing by that are not focusing their attention on the crows" (Clucas et al 2013 p299) ¹³.

The ability to recognise facial expressions would also be an advantage. Clucas et al (2013) had expected it as other studies have reported the ability (eg: rock pigeons distinguishing smile and anger; Jitsumori and Yoshihara 1997), and crows can distinguish male from female human faces (Bogale et al 2011; appendix 2A).

On the other hand, the researchers admitted, it is "possible that human facial expressions are not reliable indicators of forthcoming behaviour toward crows (as is direct eye contact), and thus, crows do not learn to associate these expression cues with subsequent rewards or dangers. Scowling or smiling may not be typically used in human-crow interactions as they are within humans" (Clucas et al 2013 p300).

2.3. APPENDIX 2A - BOGALE ET AL (2011)

Studies have found that non-human animals can distinguish different classes of stimuli, including natural objects like trees, and artificial objects like cars. The basis of the categorisation seems to be physical or perceptual similarity between objects (Bogale et al 2011).

Human faces are not common objects for many birds, and they contain a lot of visual information. For example, Troje et al (1999) found that pigeons discriminate between male and female human faces using surface features, like colour, brightness, and texture.

Bogale et al (2011) trained jungle crows (*Corvus macrorhynchos*) in Japan to distinguish between photographs of male and female human faces. Naive birds

¹³ Starlings and jackdaws also responded to human gaze, but house sparrows reacted to head orientation only in laboratory experiments with captive birds (Clucas et al 2013).

were trained individually by presenting cups containing food covered by cardboard lids. Once the birds were familiar with removing the lids to gain the food, a photograph of the face of a Japanese student (not showing the hair) was attached to the lid. In a choice test, six photographs of male students were associated with the cup containing food and the six photographs of female students with the empty cup for half the birds, and the opposite for the other half. Training was classed as complete when the birds were 80% or more correct in twenty trials.

The first experiment (generalisation test) used photographs of faces not seen before. Three of the four crows discriminated between the faces (ie: chose correct cup with food based on photograph) significantly above chance.

Bogale et al (2011) were interested in trying to establish what visual features the crows were using in the discrimination task. So, in the greyscale test. black and white photographs were used in testing after training with colour ones. The crows failed to discriminate between male and female faces, which suggested that colour was a cue used.

Then the faces were standardised into oval shapes (contour test) to control for face shape. The success of the crows was mixed, which suggested that facial contour/shape was another cue used to discriminate faces.

The next variation was the full occlusion test. After training with colour photographs of faces, the birds were presented with photographs where part of the face was covered by a large black bar - eyes, nose, mouth, mouth and eyes, eyes and nose, or mouth and nose. It was not clear if internal features of the face were used as cues to discriminate because the individual birds varied in their performance.

This led to a partial occlusion test, where small black squares covered each eye and the mouth during testing. This did not reduce the ability to discriminate the faces. So the eyes and the mouth are not important to the crows' perception of different faces.

Altogether, colour, followed by contour were the most important cues used to discriminate the male and female faces, argued the researchers. Though, in all the tests, there were individual differences in success.

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3. TOOL USE BY CROWS AND FINCHES

- 3.1. Tool use
- 3.2. Special cognitive abilities
- 3.3. Appendix 3A - Tebbich et al (2002)
- 3.4. References

3.1. TOOL USE

Tool use involves the modification of natural resources (eg: twig) into something else (eg: digging stick), and has three elements - selection of appropriate raw materials, "preparatory trimming" (basic modification), and "fine three-dimensional sculpting" (sophisticated modification) (Hunt and Gray 2004). Early human tool manufacture shows all three elements, whereas non-human tool use tends to involve selection and trimming only (Hunt and Gray 2004).

New Caledonian crows (*Corvus moneduloides*) (figure 3.1) are an exception with their hooked-twig tools, which are "sculpted". Hunt and Gray (2004) observed crows trying to get food from holes in dead logs, and collected ten "tools". The birds selected twigs joined together at a fork, and broke them off in such a way that the fork produced the hook. They continued to sculpt the twig with their bill for over one minute on average.



(Source: NormanEinstein)

Figure 3.1 - Location of New Caledonia.

The researchers concluded: "New Caledonian crows appear to have a rudimentary technology analogous to that of early humans. This rudimentary technology includes the cognitively demanding task of crafting tools" (Hunt and Gray 2004 pS89). Furthermore, it seems to be "a rudimentary grasp of the physical properties of objects or 'folk physics'" (Hunt and Gray 2004). For example, a captive female New Caledonian crow bent wire to produce a hook to obtain food (Weir et al 2002) ¹⁴. This is different to tool use by chimpanzees, say (Hunt and Gray 2004).

3.2. SPECIAL COGNITIVE ABILITIES

Tool use is seen as needing special cognitive abilities as "it involves causally relating two or more objects that are external to one's own body" (Tebbich and Bshary 2004). There is a debate as to whether only primates have such special cognitive abilities.

Woodpecker finches (*Cactospiza pallida*) ¹⁵ use twigs to pry out larvae hidden in tree holes. Tool use allows them to get large and otherwise inaccessible prey in the bark. During the dry season, they get half their prey and spend half their time using tools (Tebbich et al 2002; appendix 3A).

Parker and Gibson (1977), for example, believed that this tool use was only context-specific, stereotyped behaviour, making it different to ape tool use. But this is countered by experiments showing flexibility in woodpecker finch tool use (eg: Tebbich et al 2001).

Tebbich and Bshary (2004) assessed the ability of seventeen captured woodpecker finches on the Galapagos islands ¹⁶ (figure 3.2) on tasks used to test tool use by primates. Not all woodpecker finches use tools, so a simple test was devised first to establish who did. A beetle larva was placed in a crevice in a wooden block in the aviary and twigs were left nearby. Six birds used tools to get the food.

The first experiment involved the trap tube task. This is a transparent horizontal tube (90 mm long) that contains food (figure 3.3). At one end is a trap, and the

¹⁴ A short, straight piece of garden wire was fashioned into a hook to lift a bucket containing food from a vertical pipe. What was interesting to the researchers about the bird was that "she had no model to imitate and... no opportunity for hook-making to emerge by chance shaping or reinforcement of randomly generated behaviour. She had seen and used supplied wire hooks before but not seen the process of bending" (Weir et al 2002 p981).

¹⁵ One of fifteen species of Darwin's Finches.

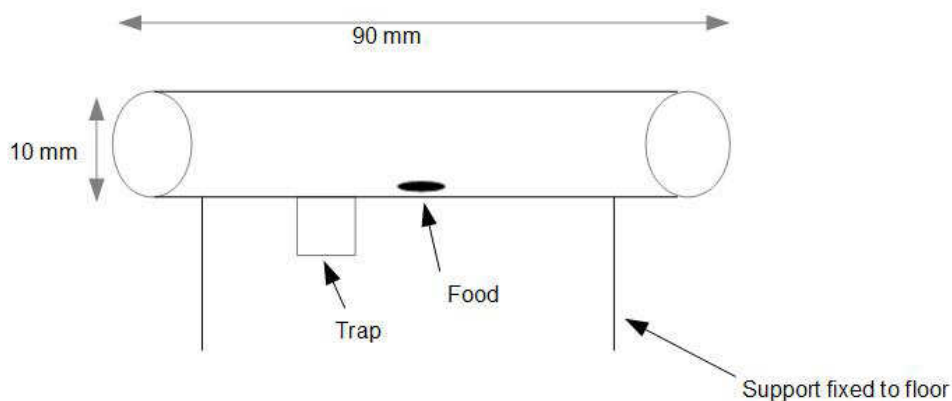
¹⁶ Charles Darwin Research Station on Santa Cruz Island, Galapagos Archipelago (Ecuador).



(Drawn with MapCeator 2.0)

Figure 3.2 - Location of Galapagos Islands.

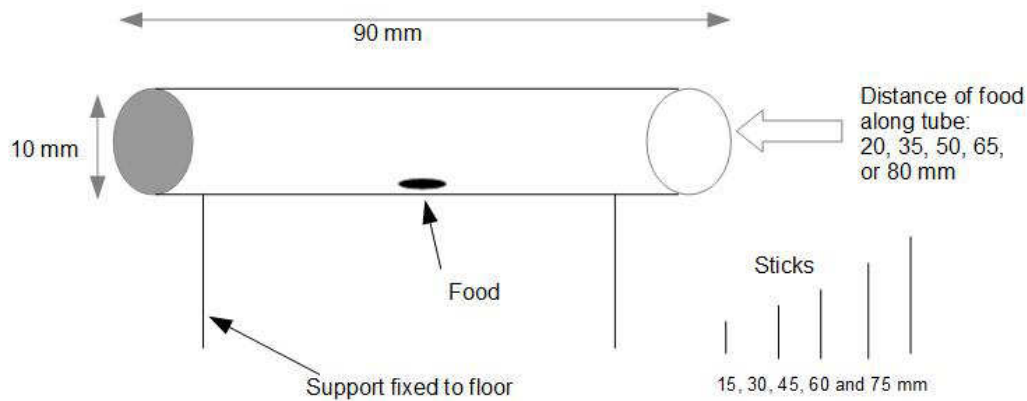
food will be lost if pushed into here. The bird can only get the food by using a stick to pull it out from one end or push away from the trap at the other end. Five birds did eighty trials each. Only one of them retrieved the food significantly above chance. This compares to three of twelve chimpanzees (Limongelli et al 1995) and one of four capuchin monkeys (Visalberghi and Limongelli 1994), who were successful in solving this task.



(Based on Tebbich and Bshary 2004 figure 1 p691)

Figure 3.3 - Apparatus for first experiment.

The second experiment tested the ability to choose the correct tool. Food was placed in a horizontal tube open at one end, and the birds were offered five sticks each of a different length to use. The position of the food was varied in the tube in each trial (figure 3.4). Three of the five birds chose the stick of the correct length more than chance (eg: "Blanco" in 81% of trials).



(Based on Tebbich and Bshary 2004 figure 3 p693)

Figure 3.4 - Apparatus for second experiment.

The third experiment challenged the birds to modify an object to make it a usable tool. Food was placed in a horizontal tube again, and H-shaped toothpicks were left nearby (figure 3.5). These had to be broken into single sticks to be useful as tools here. Three of the five birds solved this problem repeatedly. But like chimpanzees and capuchin monkeys, they initially tried to use the unmodified objects and learned that it did not fit ("trial-and-error learning"). It showed that "they were not able to understand in advance that an H-shaped tool does not fit into the tube" (Tebbich and Bshary 2004).

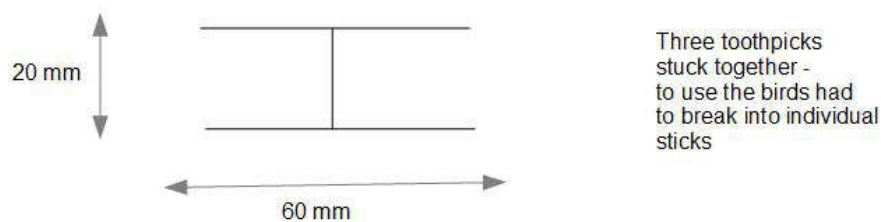


Figure 3.5 - Apparatus for third experiment.

Tebbich and Bshary (2004) concluded: "...tool use in the woodpecker finch is not a stereotypic behavioural pattern, but is open to modification by learning. Although we found no evidence for a mental representation of the physical problems, some of our subjects were able to solve the trap tube problem, modify tools for a specific task and choose tools of a sufficient length. Studies suggest that even chimpanzees do not reason about unobservable physical processes, but rather are fast learners... Tool use in the woodpecker finch also seems to be guided by a rapid process of trial and error learning" (p696).

3.3. APPENDIX 3A - TEBBICH ET AL (2002)

Tool use is key in habitats where food is scarce, and it gives the users an improved diet.

Tebbich et al (2002) observed woodpecker finches between December 1995 and April 1996, October 1996 to April 1997, and in January-February 1998. The wet season runs from January to May, and the rest of the year is the dry season. On Santa Cruz Island in the Galapagos archipelago, where the observations took place, there is an Arid Zone near the coast (semi-desert open-canopy forest) and a Scalesia Zone inland (lush evergreen cloud forest at higher elevations). Five foraging techniques (eg: inserting beak into bark) and tool use were recorded by the observers.

Tebbich et al (2002) tested three hypotheses:

i) Tool use is time-consuming, and so it is only used when prey is scarce. The median duration of prey extraction was forty seconds with tools compared to seven seconds without ($p < 0.001$), or put another way, 0.45 prey per minute versus 6.9 respectively ($p < 0.001$). But three prey types (eg: spiders) that were rich in protein were captured only by tool use.

ii) Tool use is more likely in the food-scarce Arid Zone than the food-rich Scalesia Zone. Six events of tool use in 430 minutes of observation in the Scalesia Zone versus 134 events during 845 minutes in the Arid Zone. The difference was only significant in the dry season ($p < 0.001$).

iii) Tool use is more common in the dry season. In the Arid Zone only, tool use was significantly greater in the dry than wet season (28.6% of foraging vs 4.8%; $p < 0.005$). In the Arid Zone during the dry season, energy intake was calculated as 53 calories per minute with tools compared to two without.

Tebbich et al (2002) summed up: "Our data reveal

that tool use is costly, as it takes more time to acquire prey with it than with other foraging techniques. However, during the dry season in the Arid Zone, tool use is more profitable than using conventional feeding techniques. Even though the foraging success per minute foraging time was similar with the different feeding techniques, the prey obtained with tools was significantly larger and contained more energy" (p662).

3.4. REFERENCES

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4. JUNGLE CROWS AND SPONTANEOUS NUMERICAL ABILITY

Some bird species show spontaneous numerical ability (and quantity discrimination) (ie: knowing one set of items is more than another - eg: three vs two pieces of food) (eg: jackdaws, domestic chicks), and some species can learn the ability (eg: white-necked ravens, pigeons) (Bogale et al 2014)^{17 18}.

Jungle crows (*Corvus macrorhynchos*) (figure 4.1) have been trained to discriminate between sets of non-food items (tokens) (eg: 2 vs 5, 5 vs 8, but not 5 vs 6) (Bogale et al 2011).



(Source: Micha L Rieser)

Figure 4.1 - Jungle crow.

¹⁷ Non-bird species that show spontaneous numerical ability includes horses, and salamanders, while capuchin monkeys, and dolphins, among others, can learn (Bogale et al 2014).

¹⁸ Two mechanisms are proposed for numerical representation of sets - the object-file mechanism, which compares the number of elements in each set (ie: absolute difference), and the analogue magnitude mechanism, which focuses on the relative difference between the sets (ie: ratio). Spontaneous numerical ability for small quantities is taken as support for the former mechanism, and the ability with larger quantities as support for the latter (Bogale et al 2014).

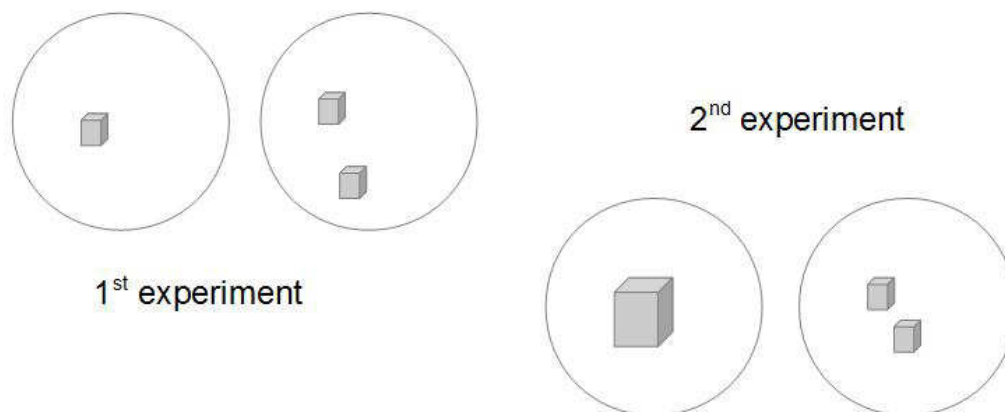
Bogale et al (2014) studied eleven untrained jungle crows at a university experimental farm in Japan. An individual bird was presented with two trays simultaneously containing the same-sized food items (spontaneous discrimination test) but with a different number of items:

- 1 vs 2, 2 vs 4, and 4 vs 8 (ratio = 0.5);
- 2 vs 3, 4 vs 6, and 8 vs 12 (ratio = 0.67);
- 3 vs 4, 6 vs 8, and 12 vs 16 (ratio = 0.75).

Each bird received nine trials (counterbalanced), and each trial was scored from video recordings based on the first choice of tray (whether the bird ate all that tray or not).

Overall, the birds had a significant preference for the larger set in each trial, except for 8 vs 12, 6 vs 8, and 12 vs 16. "Thus, the crows' performance was better for smaller magnitudes" (Bogale et al 2014).

In the second set of experiments, Bogale et al (2014) used the six choices that had been successfully distinguished by the birds (1 vs 2, 2 vs 3, 3 vs 4, 2 vs 4, 4 vs 6, and 4 vs 8), but varied the volume of food (figure 4.2). So, the smaller set had a larger volume of food making the quantity equal (eg: one large piece vs two smaller pieces). All the birds showed no preference. This was a control test to see if number or quantity was used in making the choice of food.



(Based on Bogale et al 2014 figure 1 p75 and figure 2 p76)

Figure 4.2 - Examples of spontaneous discrimination tests.

Together the two experiments showed that jungle crows had "a natural tendency towards maximising energy input". They will choose numerically more of items of the

same volume/size (up to a maximum number of 4-6 ¹⁹), but show no number preference when the overall volume is the same.

Bogale et al (2014) also noted that the "study shows that small and large quantities might be processed differently by different mechanisms in jungle crows, depending on the context of the task: spontaneous or trained. Jungle crows appear to discriminate between two large quantities better when trained than when untrained" (p77).

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¹⁹ This number fits with the average number of eggs per breeding season. There is a risk of brood parasitism (ie: extra eggs being added by the social parasite), so knowing the number of own eggs is an evolutionary advantage (Bogale et al 2014).