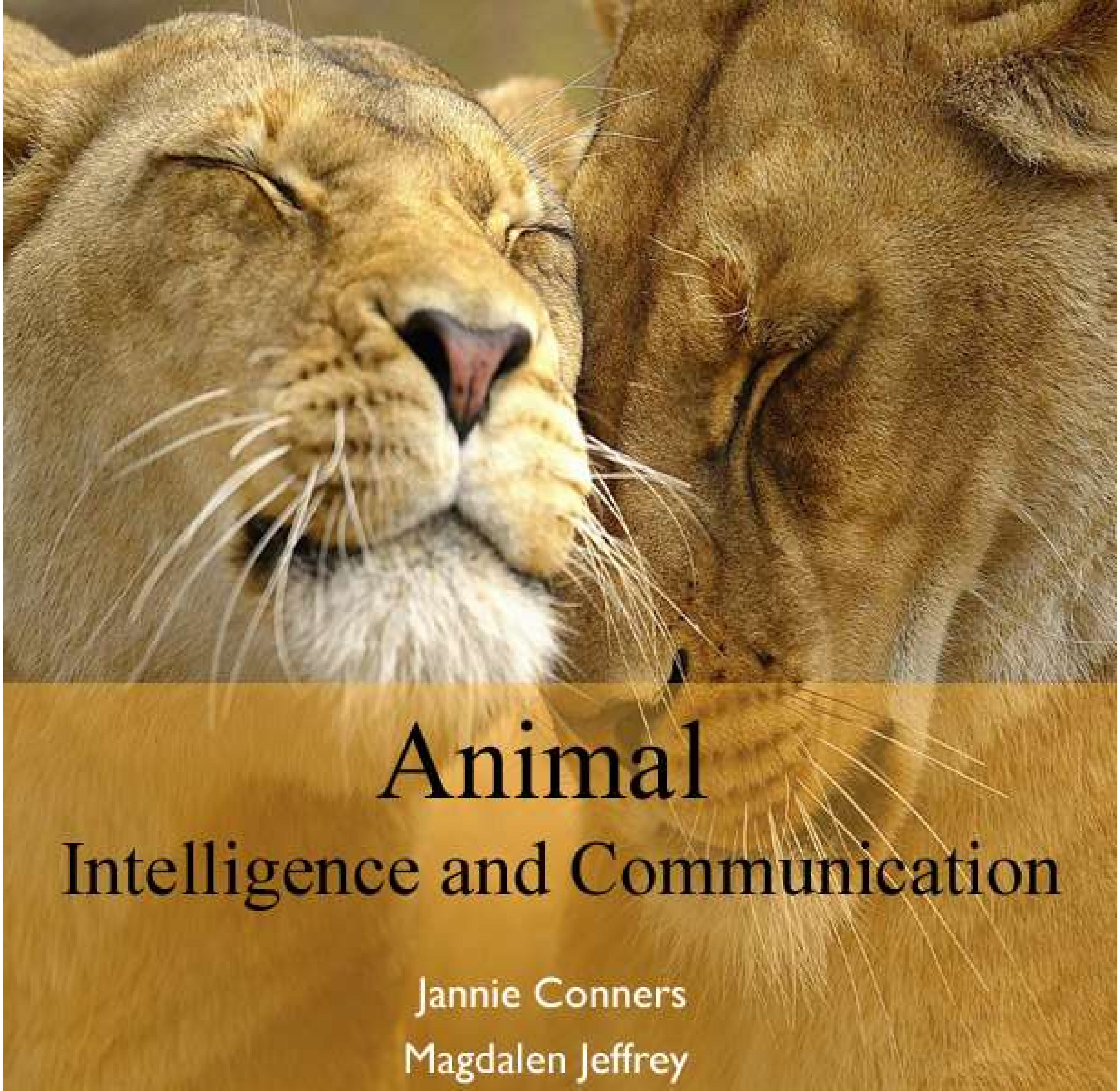


Animal
Intelligence and Communication

Jannie Conners

Magdalen Jeffrey

First Edition, 2012

ISBN 978-81-323-0677-1

Published by:
Academic Studio
4735/22 Prakashdeep Bldg,
Ansari Road, Darya Ganj,
Delhi - 110002
Email: info@wtbooks.com

Table of Contents

Chapter 1

Animal Cognition

Animal cognition is the title given to the study of the mental capacities of non-human animals. It has developed out of comparative psychology, but has also been strongly influenced by the approach of ethology, behavioral ecology, and evolutionary psychology. The alternative name cognitive ethology is therefore sometimes used; and much of what used to be considered under the title of **animal intelligence** is now thought of under this heading.

In practice, animal cognition mostly concerns mammals, especially primates, cetaceans and elephants, besides canidae, felidae and rodents, but research also extends to non-mammalian vertebrates such as birds including parrots, corvids, and pigeons, as well as lizards and fish, even to non-vertebrates such as cephalopods.

Historical background

For most of the twentieth century, the dominant approach to animal psychology was to use experiments on intelligence in animals to uncover simple learning processes (such as classical conditioning and operant conditioning) that might then account for the apparently more complex intellectual abilities of humans. This approach is well summarized in the mid-century book by Hilgard (1958), but its reductionist philosophy was combined with a strongly behaviorist methodology, in which overt behavior was taken as the only valid data for the study of psychology, and in its more extreme forms (the radical behaviorism of B. F. Skinner and his experimental analysis of behavior) behavior was taken as the only topic of interest. In effect, the mental processes that humans experience in themselves were viewed as epiphenomena (see, for example, Skinner, 1969).

The success of cognitive psychology in addressing human mental processes, which began in the late 1950s and was proclaimed by Neisser (1967), led to a re-evaluation of the research paradigm, and researchers began to address animal mental processes from the opposite direction, by taking what is known about human mental processes and looking for evidence of comparable processes in other species. In a sense this was a return to the approach of Darwin's protégé George Romanes (e.g. 1886), arguably the first comparative psychologist of the modern era. However, whereas Romanes relied heavily on anecdote and an anthropomorphic projection of human capacities onto other species, modern researchers in animal cognition are in most cases firmly behaviorist in methodology, even though they differ sharply from the behaviorist philosophy.

There are some exceptions to the rule of behaviorist methodology, such as John Lilly and, some would argue, Donald Griffin (e.g. 1992), who have been prepared to take a strong position that other animals do have minds and that humans should approach the study of their cognition accordingly. However, their claims have not found wide acceptance in the scientific community, though they have attracted an enthusiastic following among lay people.

The development of animal cognition was also strongly influenced by:

- increased use of and interest in primates (and also cetaceans) rather than the rats and pigeons that had become the classic species of the comparative psychology laboratory, and by developments within primatology;
- advancing knowledge of animals' behavior in their natural environments through studies in ethology, sociobiology and behavioral ecology; such studies often showed that animals needed certain cognitive abilities in order to adapt to their ecological niche (as for example in studies of caching birds such as Clark's Nutcracker,) or appeared to use cognitive abilities under natural conditions (for example in Jane Goodall's studies of chimpanzees;
- one or two high profile projects, in particular Allen and Beatrice Gardner's Washoe project in which a chimpanzee learned at least some elements of American Sign Language.
- advancing understanding of brain function through work in physiological psychology and cognitive neuropsychology

This account of the history of the study of animal cognition is inevitably oversimplified. From Romanes on, there have always been comparative psychologists who have been more or less cognitively inclined: obvious examples are Wolfgang Köhler, famous for his studies of insight in chimpanzees, and Edward C. Tolman, who introduced into psychology, as an explanation of the behavior of rats in mazes, two ideas that have been immensely influential in human cognitive psychology - the cognitive map and the idea of decision-making in risky choice according to expected value.

Methods

Research in animal cognition continues to use some of the established research techniques of comparative psychology and the experimental analysis of behavior, such as mazes and Skinner boxes, though it employs them in new varieties (such as the 8-arm maze and Morris water maze that have been used in many studies of spatial memory) and in new ways. However, it complements those with observation of animals in their natural environments, or quasi-natural environments and also with field experiments.

It has also been characterized by a number of very long term projects, such as the Washoe project and other ape-language experiments (e.g. project Nim), Irene Pepperberg's extended series of studies with the African Gray Parrot Alex, Louis Herman's work with bottlenosed dolphins, and studies of long-term memory in pigeons in which birds were shown to remember pictures for periods of several years. Some cognitive research also requires the management of animal behavior, and the use of operant conditioning to facilitate animal training. In general, the conclusion of concept formation in an animal requires a generalization test where the animal responds appropriately to a novel stimulus to which associative learning cannot explain the response behavior.

Some researchers have made effective use of a Piagetian methodology, taking tasks which human children are known to master at different stages of development, and investigating which of them can be performed by particular species. Others have been inspired by concerns for animal welfare and the management of domestic species: for example Temple Grandin has harnessed her unique expertise in animal welfare and the ethical treatment of farm livestock to highlight underlying similarities between humans and other animals.

Research questions

The common Chimpanzee can use tools. This chimpanzee is using a stick in order to get food.

Given the broad program of animal cognition, of looking for the animal analogs of human cognitive processes, the areas of study in animal cognition follow more or less from those in human cognitive psychology. However, progress in the different areas has been variable. Among the fields of interest are:

Attention

Research has focused on animals' ability to distribute attention between different aspects of a stimulus, and on visual search. As in humans, it appears that sharing attention between stimulus features reduces the capacity to detect any one of them, though there are some ecologically relevant visual search tasks at which particular species show remarkable abilities (for example, pigeons have an extraordinary capacity to pick out grain from substrate).

Categorization

Following pioneering research by Richard Herrnstein, there has been a mass of research on birds' ability to discriminate between categories of stimuli, including the kinds of ill-defined category that are used in everyday human speech. Birds have been found to learn this kind of task easily, and to transfer correct responses readily to new instances of the categories.

It has also been found that rhesus monkeys understand same-different relationships, easily form categories based on prototype theory, and may even have some capacity for rule-based learning.

Memory

The categories that have been developed to analyze human memory (short term memory, long term memory, working memory) have been applied to the study of animal memory, and some of the phenomena characteristic of human short term memory (e.g. the serial position effect) have been detected in animals, particularly monkeys. However most progress has been made in the analysis of spatial memory, partly in relation to studies of the physiological basis of spatial memory and the role of the hippocampus, and partly in relation to scatter-hoarder animals such as Clark's Nutcracker, certain jays, tits and certain squirrels, whose ecological niches require them to remember the locations of thousands of caches, often following radical changes in the environment.

Spatial cognition

The ability to properly navigate and search through the environment is a critical task for many animals. Research in this area (Brown & Cook, 2006) has focused on such diffuse topics as landmark and beacon use by ants and bees, the encoding and use of geometric properties of the environment by pigeons, and the ability of rats to represent a spatial pattern in either radial arm mazes or pole box mazes. Sometimes included under the envelope of spatial cognition is work in humans and other animals in visual search tasks, which aim to experimentally address questions about searching through one's environment for a particular object.

Tool and weapon use

Some species, such as the Woodpecker Finch of the Galapagos Islands, use particular tools as an essential part of their foraging behavior. However, these behaviors are often quite inflexible and cannot be applied effectively in new situations. Several species have now been shown to be capable of more flexible tool use. A well known example is Jane Goodall's observation of chimpanzees "fishing" for termites in their natural environment, and captive great apes are often observed to use tools effectively; several species of corvids have also been trained to use tools in controlled experiments, or use bread crumbs for bait-fishing .

Research in 2007 shows that chimpanzees in the Fongoli savannah sharpen sticks to use as spears when hunting, considered the first evidence of systematic use of weapons in a species other than humans.

Some cephalopods are known to use coconut shells for protection or camouflage.

Reasoning and problem solving

Closely related to tool use is the study of reasoning and problem solving. It has been observed that the manner in which chimpanzees solve problems, such as that of retrieving bananas positioned out of reach, is not through trial-and-error. Instead, they were observed to proceed in a manner that was “unwaveringly purposeful.”

It is clear that animals of quite a range of species are capable of solving a range of problems that are argued to involve abstract reasoning; modern research has tended to show that the performances of Wolfgang Köhler's chimpanzees, who could achieve spontaneous solutions to problems without training, were by no means unique to that species, and that apparently similar behavior can be found in animals usually thought of as much less intelligent, if appropriate training is given. Causal reasoning has also been observed in rooks and New Caledonian crows.

Language

The modeling of human language in animals is known as animal language research. In addition to the ape-language experiments mentioned above, there have also been more or less successful attempts to teach language or language-like behavior to some non-primate species, including parrots and Great Spotted Woodpeckers. Louis Herman published research on artificial language comprehension in the bottlenosed dolphin using cognitive research methods at the height of the skepticism produced by Herbert Terrace's criticism of chimpanzee language experiments through his own results with the animal Nim Chimpsky. In particular, the focus on the *comprehension* mode only allowed cognitive methods of utilizing blinded observers to grade the animals' gross physical behavior, rather than trying to interpret putative language *production*. Herman's results (Herman, Richards, & Wolz, 1984) were published in the journal *Cognition*, regarding work on the dolphins Akeakamai and Phoenix. All such research has been controversial among cognitive linguists.

Consciousness

The sense in which animals can be said to have consciousness or a self-concept has been hotly debated; it is often referred to as the debate over animal minds. The best known research technique in this area is the mirror test devised by Gordon G. Gallup, in which an animal's skin is marked in some way while it is asleep or sedated, and it is then allowed to see its reflection in a mirror; if the animal spontaneously directs grooming behavior towards the mark, that is taken as an indication that it is aware of itself. Self-awareness, by this criterion, has been reported for chimpanzees and also for other great apes, the European Magpie, some cetaceans and a solitary elephant, but not for monkeys. The mirror test has attracted controversy among some researchers because it is entirely focused on vision, the primary sense in humans, while other species rely more heavily on other senses such as the olfactory sense in dogs.

It has been suggested that metacognition in some animals provides some evidence for cognitive self-awareness. A dolphin, the great apes, and rhesus monkeys have demonstrated the ability to monitor their own mental states and use an "I don't know" response to avoid answering difficult questions. These species might also be aware of the strength of their memories. Unlike the mirror test, which relies primarily on body images and bodily self-awareness, uncertainty monitoring paradigms are focused on the kinds of mental states that might be linked to mental self-awareness.

A different approach to determine whether a non-human animal is conscious derives from passive speech research with a macaw. Some researchers propose that by passively listening to an animal's voluntary speech, it is possible to learn about the thoughts of another creature and to determine that the speaker is conscious. This type of research was originally used to investigate a child's crib speech by Weir (1962) and in investigations of early speech in children by Greenfield and others (1976). With speech-capable birds, the methods of passive-speech research open a new avenue for investigation.

Mathematics

Some animals are capable of distinguishing between different amounts and rudimentary counting. Elephants have been known to perform simple arithmetic and rhesus monkeys can count. Ants are able to use quantitative values and transmit this information. For instance, ants of several species are able to estimate quite precisely numbers of encounters with members of other colonies on their feeding territories. Young chimpanzees have outperformed human college students in tasks requiring remembering numbers. Pigeons have been shown to outperform humans on the Monty Hall problem, a probability puzzle.

Cognitive faculty by species

Some animals such as great apes, crows, dolphins, dogs, elephants, cats, pigs, rats, and parrots are still typically thought by laymen as intelligent in ways that some other species of animal are not. For example, crows are attributed with human-like intelligence in the folklore of many cultures. A number of recent survey studies have demonstrated the consistency of these rankings between people in a given culture and indeed to a considerable extent across cultures.

A common image is the scala naturae, the ladder of nature on which animals of different species occupy successively higher rungs, with humans typically at the top.

A more fruitful approach has been to recognize that different animals may have different kinds of cognitive processes, which are better understood in terms of the ways in which they are cognitively adapted to their different ecological niches, than by positing any kind of hierarchy.

One question that can be asked coherently is how far different species are intelligent in the same ways as humans are, i.e., are their cognitive processes similar to ours. Not surprisingly, our closest biological relatives, the great apes, tend to do best on such an assessment. Among the birds, corvids and parrots have typically been found to perform well. Despite ambitious claims, evidence of unusually high human-like intelligence among cetaceans is patchy, partly because the cost and difficulty of carrying out research with marine mammals mean that experiments frequently suffer from small sample sizes and inadequate controls and replication. Octopuses have also been shown to exhibit a number of higher-level skills such as tool use, but the amount of research on cephalopod intelligence is still limited.

Chapter 2

Tool use by Animals

Tool use by a Gorilla

An adult gorilla, possibly using a stick to gauge the depth of water

A chimpanzee gathering food with a stick

Tools are used by some animals, particularly primates, to perform simple tasks such as getting food or grooming. Originally thought to be a skill only possessed by humans, tool use requires some level of intelligence. Primates have been observed exploiting sticks and stones to accomplish tasks. Numerous bird species have also been noted as capable of using tools. The behaviour has also been observed in dolphins, elephants, otters, birds and octopi.

Opposable thumbs are a benefit in tool use, though creatures without hands have managed to use other body parts to their advantage, notably the mouth.

Types of tools

Key to identifying tool use is defining what constitutes a tool. Researchers of animal behavior have arrived at different formulations.

An object that has been modified to fit a purpose' or 'An inanimate object that one uses or modifies in some way to cause a change in the environment, thereby facilitating ones achievement of a target goal'.
—Hauser, 2000

the use of physical objects other than the animal's own body or appendages as a means to extend the physical influence realized by the animal
—Jones and Kamil, 1973
an object carried or maintained for future use
—Finn, Tregenza, and Norman, 2009.

The lack of a unique and sharp definition makes it difficult to identify many animal behaviours.

Uses

Tool use implies an animal has knowledge of the relationship between objects and their effects.

If an object is placed out of reach on a towel that itself is in reach, dogs, cats, and children will pull the towel to bring the object closer to them. But does this show knowledge about the nature of the world (declarative memory) or recall of rules already learnt (procedural)?

- Sticks can be used to break into termite nests for food or even to fight rivals. They are sometimes used for grooming.
- Stones can be used, again, to fight rivals. However, they may also be used to carve bits of wood by more intelligent animals.

Some species, such as the Woodpecker Finch of the Galapagos Islands, use particular tools as an essential part of their foraging behavior. However, these behaviors are often quite inflexible and cannot be applied effectively in new situations. Several species have now been shown to be capable of more flexible tool use. A well known example is Jane Goodall's observation of chimpanzees "fishing" for termites in their natural environment, and captive great apes are often observed to use tools effectively; several species of corvids have also been trained to use tools in controlled experiments, or use bread crumbs for bait-fishing.

Tool use by specific groups of animals

Primates

The animals that make the widest use of tools are humans, who have developed mechanical, electric and electronic tools for multiple purposes, far in advance of even the most advanced non-human animals.

Research in 2007 shows that chimpanzees in the Fongoli savanna sharpen sticks to use as spears when hunting, considered the first evidence of systematic use of weapons in a species other than humans. It has also been observed in the 1970s that some chimpanzees/bonobos use sticks as probes to collect ants and termites. Also they have been observed cutting down the stick with their fingers and teeth so that it can fit into a hole in the ants' nest. They have even been observed using two tools, a stick to dig into the ant nest and a 'brush' made from grass stems with their teeth to collect the ants.

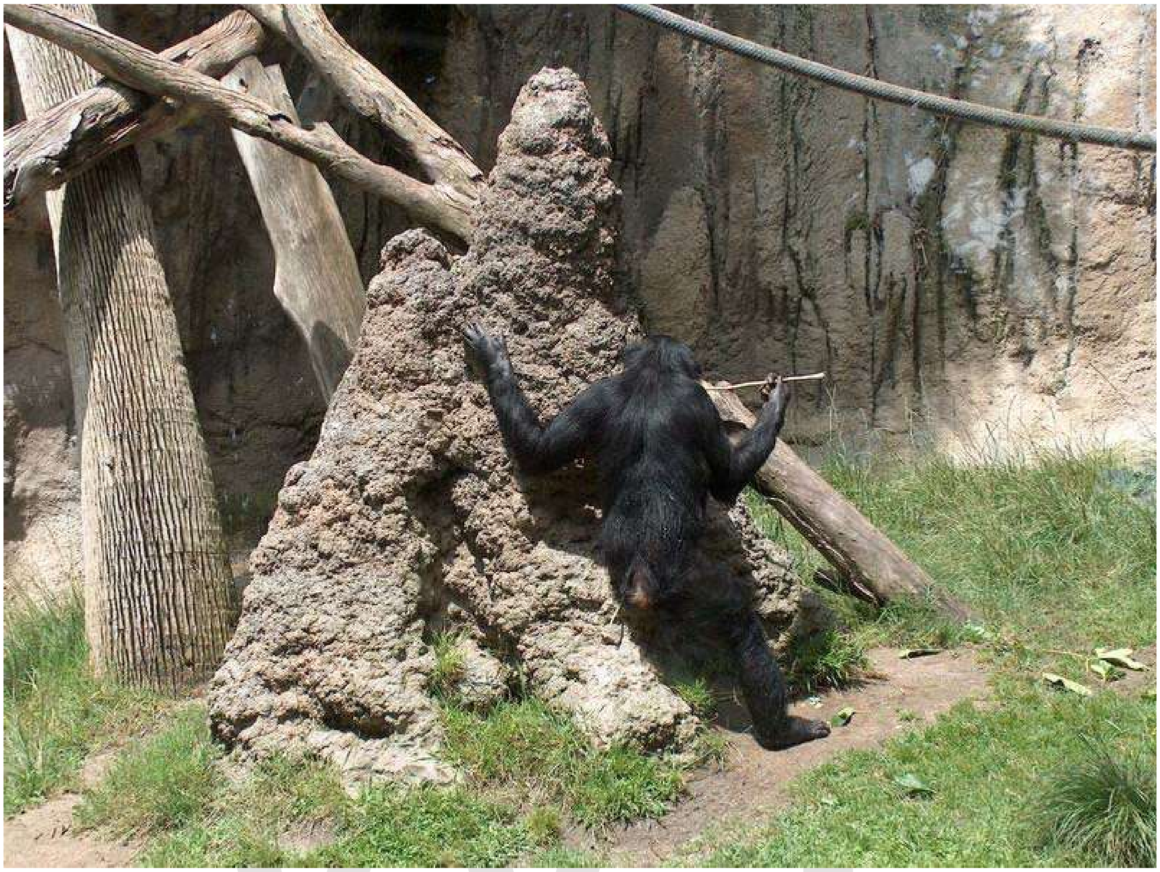
In West Africa chimpanzees have been observed banging nuts with a stone in order to crack them. Some troops use another stone whilst others use wooden clubs (heavy sticks). In one troop of chimpanzees it was observed that a female was using a stick to break into a bee hive to acquire honey. In an experiment a group of chimpanzees were presented with a model leopard with a moving head. There was soon commotion as leopards are one of the chimpanzees' predators. They were then observed clubbing the model with heavy quarterstaffs (fallen trees and/or branches). They continued doing this until the moving head had fallen off. Both bonobos and chimpanzees have also been observed making "sponges" out of leaves and moss that suck up water and are used as grooming tools.

Gorillas have been observed to use sticks to measure the depth of water and as "walking sticks" to support their posture when crossing deeper water (shown above).

Orangutans have also been observed to use sticks to measure the depth of water. It has also been observed that Orangutans in Sumatra use sticks to acquire seeds from a certain fruit. This is because the lining of the inside of the fruit has hairs that sting. On the island of Kaja a male Orangutan was observed using a pole to acquire fish from a net after observing local humans spear fishing.

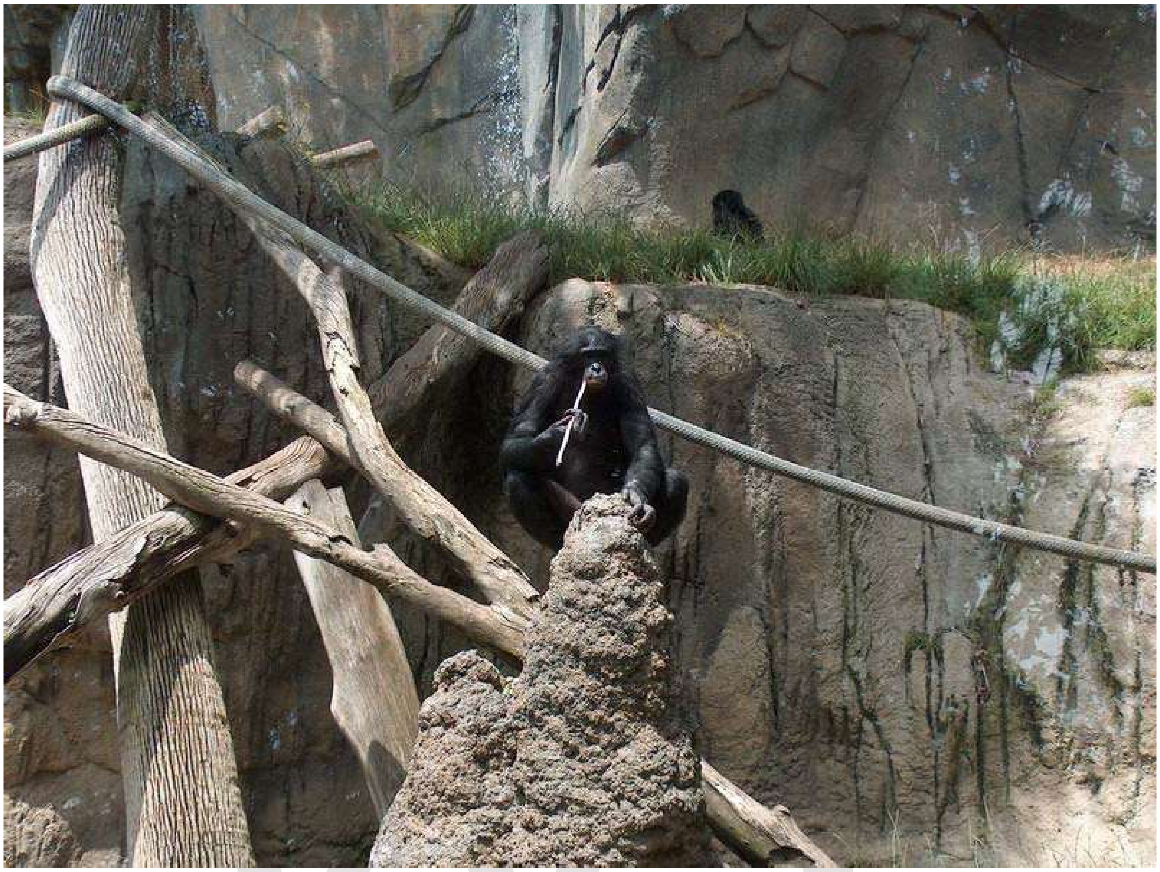
Tool use has been observed in capuchin monkeys both in captivity and in their natural environments. In a captive environment, capuchins readily insert a stick into a tube containing viscous food that clings to the stick, which they then extract and lick. Capuchins also use a stick to push food from the center of a tube retrieving the food when it reaches the far end and as a rake to sweep objects or food toward themselves .

Wild capuchin monkeys in many areas use stone hammers and anvils to crack nuts and encased seeds. They transport stones and nuts to an anvil for this purpose. Capuchins also use stones to excavate tubers and sticks to flush prey from inside rock crevices.

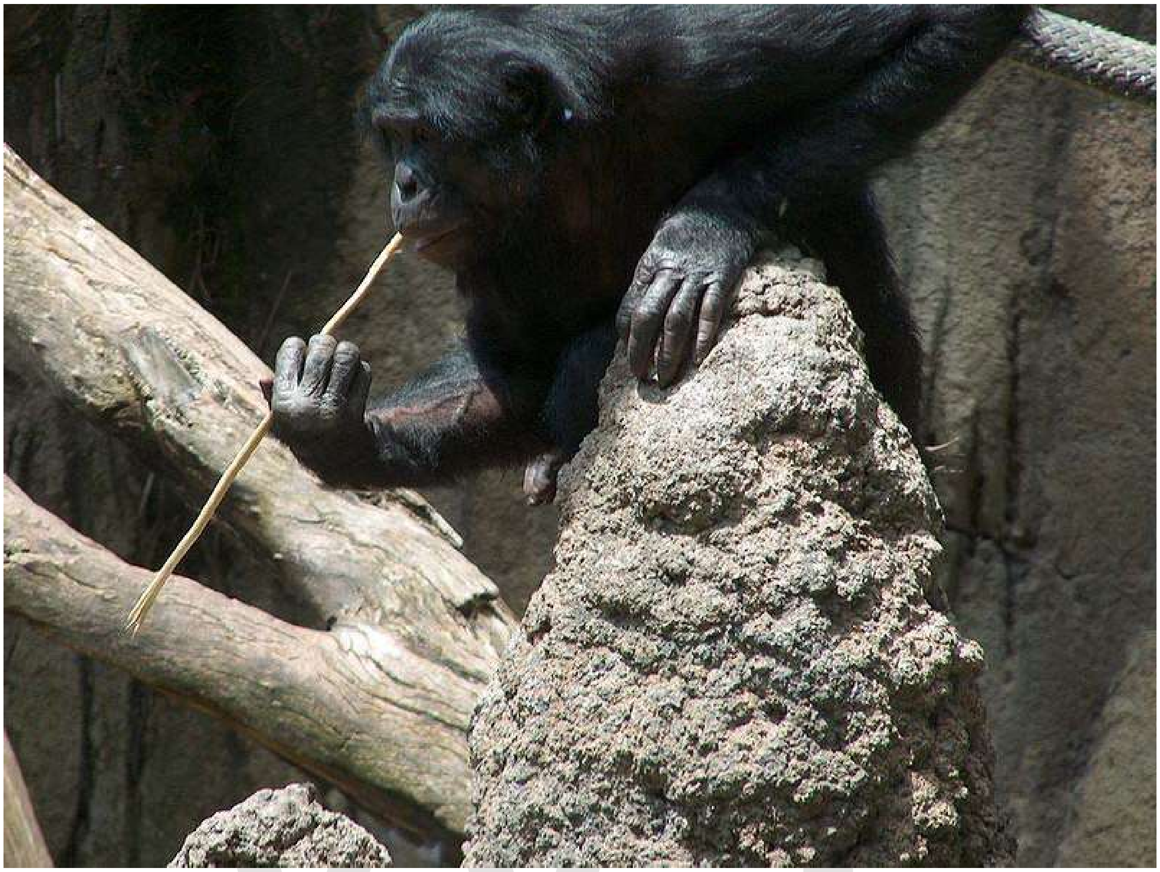


A Bonobo using a stick to 'fish' for termites in San Diego Zoo

Stage 2



Stage 3



Extracting the insects

Birds

An Egyptian vulture in flight

Many birds have been shown as capable of using tools. By Jones and Kamil's definition above, an Egyptian vulture dropping a bone on a rock would not be using a tool since the rock cannot be seen as an extension of the body. However the use of a rock manipulated using the beak to crack an ostrich egg would qualify the Egyptian vulture as a tool user. Many other species, including parrots, corvids and a range of passerines, have been noted as tool users.

New Caledonian Crows have been observed in the wild to use stick tools with their beaks to extract insects from logs. While young birds in the wild normally learn this technique from elders, a laboratory crow named "Betty" improvised a hooked tool from a wire with no prior experience. The Woodpecker Finch from the Galapagos Islands also uses simple stick tools to assist it in obtaining food. In captivity, a young Cactus Finch learned to imitate this behaviour by watching a Woodpecker Finch in an adjacent cage. Crows in urban Japan have innovated a technique to crack hard-shelled nuts by dropping them onto cross walks and letting them be run over and cracked by cars. They then retrieve the cracked nuts when the cars are stopped at the red light. In some towns in America, the crows would drop the walnuts onto busy streets and hope the cars would crack the nuts. Striated Herons (*Butorides striatus*) and Hooded Crows (*Corvus cornix*) use bait to catch fish.

A sea otter can be seen here using a rock to break open a shell.

Seagulls have been known to drop live oyster shells on paved and hard surfaces so that cars can drive over them and break the shell. So many get dropped that it is hard to drive down pavements safely near waterways. Certain species (e.g. the Herring Gull) have exhibited tool use behavior, using pieces of bread as bait with which to catch goldfish, for example.

Common ravens are one of only a few species who make their own toys. They have been observed breaking off twigs to play with socially.

Cetaceans

As of 2005, scientists have observed limited groups of Bottlenose Dolphins around the Australian Pacific using a basic tool. When searching for food on the sea floor, many of these dolphins were seen tearing off pieces of sponge and wrapping them around their "bottle nose" to prevent abrasions.

Dolphins are often seen engaging in playful behavior and create tools to use for entertainment. They have been observed to blow bubbles which they form into rings to play with. After creating the bubble ring, a dolphin will use its nose and body to maintain the shape of the bubble and keep it from floating to the surface.

Elephants

Elephants in a reserve

Elephants show a remarkable ability to use tools, despite having no hands. Instead, they use their trunk much like one would an arm. Elephants have been observed digging holes to drink water and then ripping bark from a tree, chewing it into the shape of a ball, filling in the hole and covering over it with sand to avoid evaporation. The elephant later went back to this spot for a drink. They also often use branches to swat flies or scratch themselves. Elephants have also been known to drop very large rocks onto an electric fence to either ruin the fence or cut off the electricity.

Mustelids

Sea otters have been observed using stones to hammer abalone shells off the rocks. They hammer at a rate of 45 hits in 15 seconds or 180 rpm, and do it in two-three dives.

Veined octopus

A small (4-5 cm diameter) individual using a nut shell and clam shell as shelter.

As of 2009, the octopus is the only invertebrate animal which has been conclusively shown to use tools. At least four specimens of the Veined Octopus (Amphioctopus marginatus) have been witnessed retrieving discarded coconut shells, manipulating them, transporting them some distance, stacking them and then reassembling them to use as a shelter. This discovery was documented in the journal Current Biology and has been filmed on video.

Most hermit crabs use discarded shells of other species for habitation and other crabs choose sea anemones to cultivate on their carapaces as camouflage; numerous insects use rocks, sand, leaves and so on as building materials, however none of this is classified as tool use.

Chapter 3

Talking Animal

A **talking animal** or **speaking animal** refers to any form of non-human animal which can produce sounds (or gestures) resembling those of a human language. Many species or groups of animals have developed forms of Animal Communication Systems which, to some, can look like a non-verbal language although it is not due to a lack of grammar, syntax, recursion, and displacement. Studies in animal cognition have been arguably successful in teaching some animals speech or sign, similar to but not actually sign language with Koko the gorilla. Koko was unable, however, to break-away from the here-and-now (displacement) which is just one of the many hallmarks of language Koko was unable to achieve.

A very similar perspective of study is talking animals in fiction.

On imitation and understanding

Clever Hans performs

The term may have a nearly literal meaning, by referring to animals which can imitate human speech, though not necessarily possessing an understanding of what they may be mimicking. The most common example of this would be parrots, many of which repeat many things nonsensically through exposure. It is an anthropomorphism to call this human speech, as it has no semantic grounding.

Clever Hans was a horse that was claimed to have been able to perform arithmetic and other intellectual tasks. After formal investigation in 1907, psychologist Oskar Pfungst demonstrated that the horse was not actually performing these mental tasks, but was watching the reaction of his human observers. The horse was responding directly to involuntary cues in the body language of the human trainer, who had the faculties to solve each problem, with the trainer unaware that he was providing such cues.

On formality of animal language

A "formal language" requires a communication with a syntax as well as semantics. It is not simply sufficient for one to communicate information, or even use symbology to communicate ideas. It has yet to be demonstrated that any animal species has developed a formal language, or been able to learn a formal language.

Researchers have attempted to teach great apes (Gorillas, Chimpanzees, and Bonobos) spoken language with poor results, and sign language with significantly better results. However, even the best communicating great ape has shown an inability to grasp the idea of syntax and grammar, instead communicating at best at the same level as a pidgin language in Humans. They are expressive and communicative, but lack the formality that remains such a rarity in human speech.

Reported cases by species

Birds

Research done by Dr. Irene Pepperberg strongly suggests that parrots are capable of speaking in context and with intentional meaning. Pepperberg's star pupil, Alex the African Grey Parrot, had demonstrated the ability to assemble words out of letters—in other words, to read and spell.

Dogs

- Odie, the talking pug that will say a convincing "I love you" on demand has made appearances on Letterman and on The Montel Show and on AOL's "T.V. top 5".
- Paranormal researcher Charles Fort wrote in his book *Wild Talents* (1932) of several alleged cases of dogs that could speak English. Fort took the stories from contemporary newspaper counts, but they are unverifiable at this late date.
- Internet phenomenon, Mishka the talking Husky, has been trained to say certain phrases, most notably "I love you", and has videos of her saying phrases like "Hello", "NOOOOO", and also has learned to sing through the help of an iPad.

Cats

- A talking cat called Cingene (Gypsy) made Turkish television news on March 20, 1993. The two year old black cat managed to say at least seven words on television.

- A more recent Internet phenomenon is the case of a cat who was videotaped speaking recognizable human words and phrases such as "Oh my dog," "Oh Don piano", and "All the live long day." Footage of this cat, nicknamed "Oh Long Johnson" from one of the phrases spoken, was featured on *America's Funniest Home Videos* in 1998, and a longer version of the clip (which revealed the animal was speaking to another cat) was later aired in the UK. Clips from this video are prevalent on YouTube.

Tiggy the talking cat at home

- Another recent Internet phenomenon is the cat named Tiggy. Tiggy the Talking Cat (1990 - June 23rd 2010) was a unique cat who made a unique talking like noise. Tiggy is from Grimsby, England and was born in 1990; she died on Wednesday 23rd June 2010 at the age of 20.

Tiggy started making this strange noise at around the age of 8 and would only make it when she was alone and out of sight. After years of hearing the noise and never seeing it being made, in May 2007 out of curiosity as to what Tiggy looked like when making this noise (and also to show it to friends who didn't believe the cat could talk) her owners set up a video camera and left it on record in a spot where Tiggy regularly "spoke", eventually footage was captured of Tiggy sitting in the hallway making the noise which sounded like "Hello" four times. This video was uploaded to youtube and was the first ever Tiggy video. In the first Tiggy video she was quite a distance from the camera so the owners tried again, the second attempt was a great success with Tiggy walking up to the camera and talking for around 20 seconds. The video captured the second time was also uploaded to YouTube along with the first video and it became a huge hit acquiring millions of views on YouTube turning Tiggy into an internet celebrity. A further video was then filmed in the same house and uploaded to Youtube in June, no more videos of tiggy appeared on YouTube until August 2009 when videos of Tiggy playing and talking were uploaded. Footage of Tiggy has made its way on to several TV Shows in Both the USA and the U.K. Tiggy's first T.V appearance was in the U.K. on channel 4's Richard and Judy show during the "funny five" segment of the show which consisted of 5 funny videos from the internet being nominated by a different celebrity guest each week, viewers then voted for their favorite online. Tiggy won the Funny Five competition for the 2007 series of the show and the crew visited Tiggy in her home and presented her with a plaque signed by presenters Richard and Judy, it was Tiggys appearance on this show which helped to make her popularity on YouTube so large with her being featured on the main YouTube page due to the huge amount of views the TV appearances caused. Tiggy has then gone on to appear on a number of shows all over the world including: CBBC's Chute, BBC's Lenny Henry.tv, America's County Fried Home Videos, The Ellen DeGeneres and various shows on Animal Planet.

- Miles v. City Council of Augusta, Georgia

Other

- Hoover, a harbor seal that would vocally repeat common phrases he heard around his exhibit at the New England Aquarium, including his name. He appeared in publications like *Reader's Digest* and *The New Yorker* and television programs like *Good Morning America*.

- Gef the talking mongoose was an alleged talking animal who inhabited a small house on the Isle of Man, off the coast of Great Britain. Opinion is divided on whether Gef was a poltergeist, a strange animal or cryptid, a hoax, or something else. Most doubt the case happened at all as told.

- Batyr (1969–1993), an elephant from Kazakhstan, was widely published as having a vocabulary of more than 20 phrases. Recordings of Batyr saying "Batyr is good","Batyr is hungry" and using words such as "drink" and "give" was played on Kazakh state radio in 1980.

- Kosik (1990—), an elephant able to imitate some Korean words

Chapter 4

Bird Intelligence

Kea are known for their intelligence and curiosity, both vital to their survival in a harsh mountain environment. Kea can solve logical puzzles, such as pushing and pulling things in a certain order to get to food, and will work together to achieve a certain objective, and some have the intelligence of an average six-year-old.

Bird intelligence deals with the definition of intelligence and its measurement as it applies to birds. Traditionally, birds have been considered inferior in intelligence to mammals, and derogatory terms such as *bird brains* have been used colloquially in some cultures. Such perceptions are no longer considered scientifically valid. The difficulty of defining or measuring intelligence in non-human animals makes the subject difficult for scientific study. Anatomically, a bird has a relatively large brain compared to head size. The visual and auditory senses are well developed in most species, while tactile and olfactory senses are well developed only in a few groups. Locomotion is achieved through flight and use of the legs in most species. The beak and feet are used to manipulate food and other objects. Birds can communicate using visual signals as well as through the use of calls and song. The testing of intelligence is therefore based on studying the responses to sensory stimuli.

Studies

Cormorants used by fishermen in Southeast Asia may be able to count

Bird intelligence has been studied through several attributes and abilities. Many of these studies have been on birds such as quail, domestic fowl and pigeons kept under captive conditions. It has, however, been noted that field studies have been limited, unlike those of the apes. Birds such as the corvids and psittacines have been shown to live social lives, have long developmental periods and large forebrains, and these may be expected to have greater cognitive abilities.

Counting

Counting has been considered an ability that shows intelligence. Early anecdotal evidence has suggested that crows may count up to 3. Researchers however need to be cautious and ensure that birds are not merely demonstrating the ability to subitize. Some studies have suggested that crows may indeed have a true numerical ability. Parrots have been shown to count up to 6.

Cormorants used by Chinese fishermen that were given every eighth fish as a reward were found to be able to keep count up to eight.

In the 1970s, on the Li River, Pamela Egremont observed fishermen who allowed the birds to eat every eighth fish they caught. Writing in the Biological Journal of the Linnean Society, she reported that, once their quota of seven fish was filled, the birds "stubbornly refuse to move again until their neck ring is loosened. They ignore an order to dive and even resist a rough push or a knock, sitting glum and motionless on their perches." Meanwhile, other birds that had not filled their quotas continued to catch fish as usual. "One is forced to conclude that these highly intelligent birds can count up to seven," she wrote.
—Hoh, E. H.

Many birds are also able to detect changes in the number of eggs in their nest and brood. Parasitic cuckoos are often known to remove one of the host eggs before laying their own.

Associative learning

Visual or auditory signals and their association with food and other rewards have been well studied and birds have been trained to recognize and distinguish complex shapes. This is probably an important ability that aids their survival.

Spatial and temporal abilities

A common test of intelligence is the detour test. Here a glass barrier between the bird and an item such as food is used in the setup. Most mammals discover that the objective is reached by first going away from the target. Domestic fowl fail on this test. Many corvids were found to readily solve the problem.

Large fruit-eating birds in tropical forests depend on trees which fruit at different times of the year. Many species, such as pigeons and hornbills, have been shown to be able to decide upon foraging areas according to the time of the year. Birds that show food caching behaviour have also shown the ability to recollect the locations of food caches. Nectarivorous birds such as hummingbirds also optimize their foraging by keeping track of the locations of good and bad flowers. Studies of Western Scrub Jays (*Aphelocoma californica*) also suggests that birds may be able to plan for the future. They cache food according to future needs and risk of not being able to find the food on subsequent days.

Many birds follow strict time schedules in their activities. These are often dependent upon environmental cues. Birds also are sensitive to daylight length, and this awareness is especially important as a cue for migratory species. The ability to orient themselves during migrations is attributed to birds' superior sensory abilities, rather than to intelligence.

Self awareness

To check if an animal possesss or lacks the ability to recognize itself in its own reflection shows if they are conscious of themselves and able to distinguish themselves and from other animals, this is done by using the mirror test. The European Magpie is the only animal, besides a mammal that is shown to be able to pass this test by trying to remove a coloured sticker from underneath their beaks when shown in a mirror. However in 1981, Epstein, Lanza and Skinner published a paper in the journal Science in which they argued that the pigeon also passes the mirror test. A pigeon was trained to look in a mirror to find a response key behind it which the pigeon then turned to peck - food was the consequence of a correct choice (i.e., the pigeon learned to use a mirror to find critical elements of its environment). Next, the pigeon was trained to peck at dots placed on its feathers; food was, again, the consequence of touching the dot. The latter training was accomplished in the absence of the mirror. The final test was placing a small bib on the pigeon - enough to cover a dot placed on its lower belly. A control period without the mirror present yielded no pecking at the dot. When the mirror was revealed, the pigeon became active, looked in the mirror and then tried to peck on the dot under the bib. It is true that untrained pigeons have never been able to pass the mirror test. However, pigeons do not normally have access to mirrors and do not have the necessary experiences to use them. Giving the pigeons this experience in no way guaranteed it would pass the mirror test - remember, the pigeon never pecked dots on its own body in the presence of the mirror (until the final test). Despite that they are not classified as being able to recognize their reflection, because the pigeons that did were trained to do so and the animal has to be able to do this without the assistance of a person. Therefore it must also be shown to be able to do this in the wild as well with no experience, but just intelligence to see if it is able to comprehend that it is looking at its own reflection on its own. However even when an animal is trained to do this it's still unknown if they are aware that they are looking at themselves, or are just repeating the same movements and commands that they were taught so that they may receive a treat as a reward after they have correctly completed their task.

Tool use

Many birds have been shown capable of using tools. The definition of a tool has been debated with no consensus being reached. One proposed definition of tool use has been defined as

the use of physical objects other than the animal's own body or appendages as a means to extend the physical influence realized by the animal
—Jones and Kamil, 1973

By this definition, a Lammergeier dropping a bone on a rock would not be using a tool since the rock cannot be seen as an extension of the body. However the use of a rock manipulated using the beak to crack an ostrich egg would qualify the Egyptian vulture as a tool user. Many other species, including parrots, corvids and a range of passerines, have been noted as tool users.

New Caledonian Crows have been observed in the wild to use stick tools with their beaks to extract insects from logs. While young birds in the wild normally learn this technique from elders, a laboratory crow named "Betty" improvised a hooked tool from a wire with no prior experience. The Woodpecker Finch from the Galapagos Islands also uses simple stick tools to assist it in obtaining food. In captivity, a young Cactus Finch learned to imitate this behaviour by watching a woodpecker finch in an adjacent cage. Crows in urban Japan have innovated a technique to crack hard-shelled nuts by dropping them onto crosswalks and letting them be run over and cracked by cars. They then retrieve the cracked nuts when the cars are stopped at the red light. Striated Herons (*Butorides striatus*) use bait to catch fish.

Observational learning

Learning using rewards to reinforce responses is often used in laboratories to test intelligence. However, the ability of animals to learn by observation and imitation is considered more significant. Crows have been noted for their ability to learn from each other.

Brain anatomy

At the beginning of the 20th century, scientists argued that the birds had hyper-developed basal ganglia, with tiny mammalian-like telencephalon structures. Modern studies have refuted this view The basal ganglia only occupy a small part of the avian brain. Instead, it seems that birds use a different part of their brain, the medio-rostral neostriatum/hyperstriatum ventrale as the seat of their intelligence, and the brain-to-body size ratio of psittacines and corvines is actually comparable to that of higher primates.

Studies with captive birds have given insight into which birds are the most intelligent. While parrots have the distinction of being able to mimic human speech, studies with the African Grey Parrot have shown that some are able to associate words with their meanings and form simple sentences. Along with parrots, the crows, ravens, and jays (family Corvidae) are perhaps the most intelligent of birds. Not surprisingly, research has shown that these species tend to have the largest HVCs. Dr. Harvey J. Karten, a neuroscientist at UCSD who has studied the physiology of birds, has discovered that the lower parts of avian brains are similar to those of humans.

Social behaviour

Social life has been considered to be a driving force for the evolution of intelligence. Many birds have social organizations, and loose aggregations are common. Many corvid species separate into small family groups (or "clans") for activities such as nesting and territorial defense. The birds then congregate in massive flocks made up of several different species for migratory purposes. Some birds use teamwork while hunting. Predatory birds hunting in pairs have been observed using a "bait and switch" technique, whereby one bird will distract the prey while the other swoops in for the kill.

Social behaviour requires individual identification, and most birds appear to be capable of recognizing mates, siblings and young. Other behaviours such as play and cooperative breeding are also considered indicators of intelligence.

When crows are caching food, they appear to be sensitive to note who is watching them hide the food. They also steal food caught by others.

In some fairy-wrens such as the Superb and Red-backed, males pick flower petals in colors contrasting with their bright nuptial plumage and present them to others of their species that will acknowledge, inspect and sometimes manipulate the petals. This function seems not linked to sexual or aggressive activity in the short and medium term thereafter, though its function is apparently not aggressive and quite possibly sexual.

Language

Birds communicate with their flockmates through song, calls, and body language. Studies have shown that the intricate territorial songs of some birds must be learned at an early age, and that the memory of the song will serve the bird for the rest of its life. Some bird species are able to communicate in a variety of dialects. For example, the New Zealand saddleback will learn the different song "dialects" of clans of its own species, much as human beings might learn diverse regional dialects. When a territory-owning male of the species dies, a young male will immediately take his place, singing to prospective mates in the dialect appropriate to the territory he is in.

Recent studies indicate that some birds may have an ability to understand grammatical structures.

Conceptual abilities

Evidence that birds can form abstract concepts such as *same–different* has been proven by *Alex*, the African grey parrot. Alex was trained to vocally label more than 100 objects of different colours and shapes and which are made from different materials. Alex could also request or refuse these objects ('I want X') and quantify numbers of them.

It has been noted that bird brainwaves are very similar to that of humans, there are many similarities between the lobes of the brain and most notable the cerebral cortex. For this reason it is believed they can understand human language.

Theory of mind

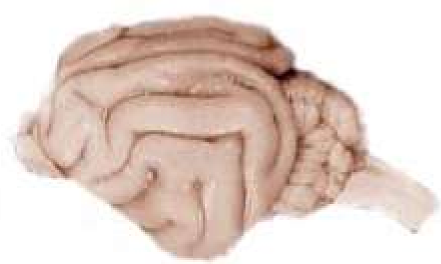
A study on the Little Green Bee-eater suggests that these birds may be able to see from the point of view of a predator. The Western Scrub Jay hides caches of food and will later re-hide food if it was watched by another bird the first time, but only if the bird hiding the food has itself stolen food before from a cache. This might suggest a theory of mind, but other "lower level" explanations are possible. Such an ability to see from the point of view of another individual had previously been attributed only to the great apes. Such abilities form the basis for empathy. Research conducted with an Eleonora Cockatoo named Snowball has shown that birds can learn to dance to human-made music.

Chapter 5

Cat Intelligence

Cat intelligence is the considered capacity of learning, thinking, problem solving, reasoning, and adaptability possessed by the domestic cat. Intelligence in cats is demonstrated by the capacity to develop and use tools, learn new behavior techniques, apply previously acquired knowledge to new situations, communicate needs and desires within social groups, and respond to training cues. Mammalian neuroscientists have attempted to simulate the feline brain in order to understand the origins and operation of cat intelligence, but results to date are inconclusive and additional study is needed.

Brain size and surface area



The brain of a cat

The brain size of the average cat is 5 centimeters in length and 30 grams. Since the average cat is 60 cm long and 3.3 kg, the brain makes up 1/12 of its length and 1/110 of its mass. Thus, the average cat's brain accounts for 0.9 percent of its total body mass, compared to 2 percent of total body mass in the average human. The surface area of a cat's cerebral cortex is approximately 83 cm². The modern human cerebral cortex is about 2500 cm². According to researchers at Tufts University School of Veterinary Medicine, the physical structure of human brains and that of cats are very similar; they have the same lobes in the cerebral cortex (the "seat" of intelligence) as humans do. Human brains also function the same way, conveying data via many identical neurotransmitters.

The learning cat

It is proven that cats learn by trial and error, observation and imitation. They retain certain information (such as the ability to investigate new environments) much longer than dogs. In one study, it was found that cats possess visual memory ability comparable to that of monkeys.

Intelligence by breed

Ranking the intelligence of cats by breed is popular among pet owners, veterinarians and others, but the practice tends to run into difficulties. In general, the subject of cat intelligence rankings tends to be subjective. Cat breeder Norman Auspitz states the following: "As a rule, people seem to think the more active breeds have higher intelligence than the less active breeds. I will tell you that in feline agility, all breeds have done very well or very poorly as the case may be.. Having said that, there is no certified measure of cat intelligence and this general rule may be very anthropomorphic... until there is a credible definition of what might be meant by cat intelligence and a way to measure it, any comment anyone will make about the subject is, at best, speculation. Although, Siamese seem to be one of the more intelligible breeds, in terms of problem solving and communication skills. "

Observed abilities of cats

Inventing and using a tool

At least one cat was documented by a scientist to have adapted an object for use as a tool to add water to dry cat food, this tool-use being invented by the cat without any prior training by humans.

Opening doors and windows

Cats that are accustomed to being let outside, or that want to get into their home, may learn to open windows and doors. They are capable of learning different routes for entry and exit; for instance a cat might find the window in its owner's kitchen easier to open to exit the house, but to get in, they might have to use the screen door in the backyard. Also, they may learn to open cupboard doors to get to food. Cats' paws are not as effective at manipulation as human hands, owing to lack of an opposable thumb, but they can for instance learn to operate door lever handles by pulling them down, even though gripping the handle is difficult for cat paws.

Retrieving items from hard to reach places

A cat playing with a ball may suddenly find that the ball is under the couch. The cat will try different ways, changing paws, position, and other elements, the way a human would. This trial and error approach to puzzle solving can be demonstrated in the laboratory using Thorndike's puzzle boxes. In these boxes, cats must manipulate a series of levers in order to escape. They initially achieve this by trial and error, before committing the sequence to memory. They also use memory to reduce the amount of trial and error when encountering comparable novel situations e.g. new puzzle boxes. The cat may also be taught to get treats from high and hard to reach places, like on top of a refrigerator, or in a cupboard. Using the same logic as it did with the toy, the cat will get to each treat. A cat that has figured out where the cat food is kept may find that the food is inside a large bag. It might try to get in the bag or open it by means of removing the clip.

Using the toilet

Toilet trained cat

Because of their sensitive sense of smell, some cats prefer going outside to urinate and defecate, and rarely go in the same spot twice. Kittens are typically trained by their mothers to use a litter box and cover up their waste, so litter training rarely requires human intervention; once they understand where the litter box is, they will seek it out from then on. Cats can also be trained to make use of a toilet; some cats learn on their own after watching their owners, but for most cats, it is necessary to be taught by owners. In general, however, a toilet-trained cat is a rare animal, and successful toilet training depends both on the willingness of the animal to learn as well as on the patience of the owner to teach.

Playing fetch

Some cats can be trained to play fetch with a varied degree of success (which is dependent on the cat and its mood). Siamese, Bengals and Burmese cats are well-regarded as breeds that naturally carry objects in their mouths. They are easy to train to fetch and carry, again it may come naturally. Other breeds such as the Egyptian Mau, Maine Coon, Turkish Van, Savannah, Short Hair and Turkish Angora, and Bombay are also well known for an almost dog-like affinity for playing fetch; at least one Bombay started the game with its owner and trained the owner. It is possible to get a cat to remain seated until an object is thrown. At that point, their sense of sight kicks in. As long as there is at least a remote chance of locating the thrown item, the cat will run off to find it. Once retrieved, waiting or a simple call is enough for the cat to return with the item (if it does not chose to do it themselves) and deposit it (usually) within arm's reach (or just outside as a possible form of dominance, making the owner change position). Chasing an object in the air is a natural cat hunting behavior, and many cats will chase down a thrown toy for the sheer enjoyment of running and catching. Of course, any distraction and the cat may completely forget the game. This might suggest that a dog, which will do almost anything to please its owner due to pack instinct, will tend to focus on its game for both the owner and its pleasure, while a cat clearly plays the game for its own self-interest in chasing and pouncing. For a dog, the reward for a retrieved toy may be a vigorous petting or vocalization of praise and also a second toss, for a cat, the only reward is typically the second throw.

Communication

Cats, like many animals, communicate in a social environment in various ways. Some aspects of this behaviour are simple, such as purring to express the desire for and enjoyment of attention, meowing near the food bowl to get fed, some remember what time they get fed and attempt to gain their owner's attention at that time every day, etc., and some are more complex. Domestic cats organize themselves in complex social units when food is plentiful and conditions are otherwise conducive to it. It is actually quite important to cats' welfare to understand that they are not 'solitary by nature.' Although they do not socialize in the same way that dogs do (they do not hunt in packs, for example, and are not responsive to praise and blame in the same way) they still associate themselves strongly with specific other animals (including humans) and are probably even more attached to place and routine than dogs or their human owners. Cats may tend to communicate more indirectly, that is if they want their owner to open a door or pick up a favorite toy, they will often stare at the object intently with only occasional looks to the owner, until the owner, noting the focus of the cat, will look to where the cat is looking. Cats will often place themselves in favorite positions where some behavior of the owner is expected. These positions are not always related to conditioning, but possibly from the cat remembering that the last time it was in this particular position something it wanted to happen, happened. Unlike true conditioning, however, the cat can easily adjust to new positions to get to the same object of its desire. Whether this is a sign of intelligence or a lack of intelligence is perhaps unfathomable as cats show so much individualized behavior.

Training and tricks

Cats are traditionally hard to train as circus animals, mainly because cats appear to only assume such behaviors in exchange for a direct benefit, unlike dogs which respond well to emotional reassurance. While this is usually true, a human with a good relationship to a cat, where there is trust and good communication, can find a cat to be almost as trainable as a dog. A good example of this is The Yuri Kuklachev Cat Theatre based in Moscow , the owner of which has been training cats for many years to do a full range of circus style tricks. Also there is the belief that cats are harder to train than dogs owing to impatience and boredom with the training exercise. Like dogs and people, many cats have active minds that thrive on stimulation, exploration and learning. Many of the same basic methods of training a dog—shaping behavior, and giving reinforcement in the form of treats, lavish praise or attention for correct responses—work extremely well when training a cat. A cat can be taught to "sit" for treats or meals; this or other such repeatable behaviour responses can act as a foundation for further training.

Computer simulation of the cat brain

Scientists have simulated a cat's cerebral cortex, the thinking part of the brain, using a massive supercomputer. However, the reports have raised controversy, because the computer does not actually think like a cat. The computer simulation is cat-*scale*, meaning that the simulation is powerful enough to simulate a cat brain, but it is not a proper, realistic simulation of a cat brain. Conflicting views comment on the fact that the simulation uses a faithful reproduction of the neurons in the brain, and also argue that the simulation does not use biologically realistic simulations of the neurons in a cat brain. Other arguments point out the motives for reverse-engineering a cat brain, as there are tensions between the goals of the simulation. Neuroscientists want to understand how the brain's architecture, using biological neurons, leads to consciousness and neurological disorders, whereas computer scientists want to understand brain architecture in order to create new kinds of electronics.

There are a number of reasons the cat brain is a goal of computer simulations. Cats are a familiar and easily-kept animal, so the physiology of cats has been particularly well studied. The physical structure of human brains and cat brains are very similar. Cats, like humans, have binocular vision that gives them depth perception.

Building artificial mammal brains requires ever more powerful computers as the brain gets more complex, from the mouse brain, to the rat brain (in 2007), to the cat brain, and ultimately to the human brain. Building artificial mammal brains advances the research of both neuroscience and artificial intelligence, but also leads to questions of the definition of sentient and conscious life forms, and to the ethics of artificial consciousness.

Chapter 6

Cephalopod Intelligence

An octopus in a zoo

Cephalopod intelligence has an important comparative aspect in the understanding of intelligence, because it relies on a nervous system fundamentally different from that of vertebrates. The cephalopod class of molluscs, particularly the Coleoidea subclass (cuttlefish, squid and octopuses), are considered the most intelligent invertebrates and an important example of advanced cognitive evolution in animals.

The scope of cephalopod intelligence is controversial, complicated by the challenges of studying these elusive and fundamentally different creatures. Classical conditioning of cephalopods has been reported, and one study (Fiorito and Scotto, 1992) even concluded that octopuses practise observational learning. However, the latter idea is strongly disputed, and doubt has been shed on some other reported capabilities as well. In any case, impressive spatial learning capacity, navigational abilities, and predatory techniques remain beyond question.

Examples of intelligence

Predation techniques

Unlike most other molluscs, all cephalopods are active predators (with the possible exception of the bigfin squid). Their requirement to locate and capture their prey has been a probable driving force behind the development of their intelligence, uniquely advanced in their phylum.

The humboldt squid hunts schools of fish, showing extraordinary cooperation and communication in its hunting techniques. This is the first observation of such behaviour in invertebrates.

Crabs, the staple food source of most octopus species, present significant challenges with their powerful pincers and their potential to exhaust the cephalopod's respiration system from a prolonged pursuit. In the face of these challenges, octopuses will instead seek out lobster traps and steal the prize inside. They are also known to climb aboard fishing boats and hide in the containers that hold dead or dying crabs.

Dexterity

Dexterity, an ability essential for tool use and manipulation is also found in cephalopods. The highly sensitive suction cups and prehensile arms of octopuses, squid, and cuttlefish are as effective at holding and manipulating objects as the human hand. However, unlike vertebrates, the motor skills of octopuses do not seem to depend upon mapping their body within their brains, as the ability to organize complex movements is not thought to be linked to particular arms.

One particularly clever octopus called Otto has been known to juggle his fellow tankmates around out of boredom, as well as throwing rocks and smashing the aquarium glass. On more than one occasion he even caused short circuits by crawling out of his tank and shooting a jet of water at the overhead lamp.

Octopus opening a container with a screw cap

Communication

Another example of cephalopod intelligence is the communication that takes place between the more social species of squid. Some cephalopods are capable of rapid changes in skin color and pattern through nervous control of chromatophores. This ability almost certainly evolved primarily for camouflage, but squids use color, patterns, and flashing to communicate with one another in various courtship rituals. Caribbean Reef Squid can send one message via color patterns to a squid on their right, while they send another message to a squid on their left.

Tool use

As of 2009, the octopus is the only invertebrate animal which has been conclusively shown to use tools. At least four specimens of the Veined Octopus (*Amphioctopus marginatus*) have been witnessed retrieving discarded coconut shells, manipulating them, transporting them some distance, and then reassembling them to use as a shelter. This discovery was documented in the journal *Current Biology* and has been filmed on video. Most hermit crabs use discarded shells of other species for habitation and other crabs choose sea anemones to cultivate on their carapaces as camouflage; numerous insects use rocks, sand, leaves and so on as building materials, however none of this behavior compares to the complexity of the octopus's fortress behavior, which involves picking up and carrying a tool to use later on.

Chapter 7

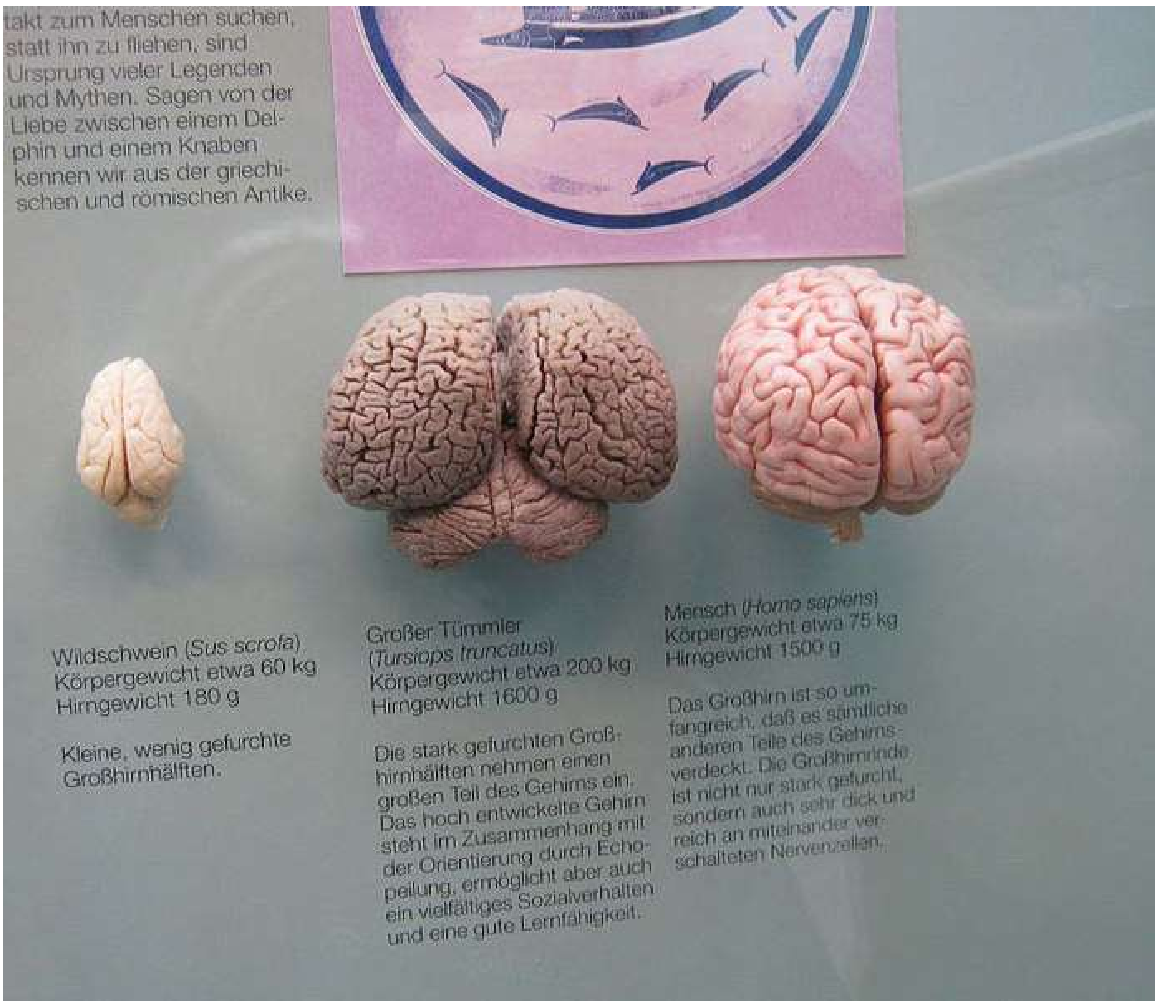
Cetacean Intelligence

Akeakamai, a bottlenose dolphin, was a subject in an animal language study at the Kewalo Basin Marine Mammal Laboratory in Oahu, Hawaii.

Cetacean intelligence denotes the cognitive capabilities of the Cetacea order of mammals, which includes whales, porpoises, and dolphins.

Brain size

Brain size used to be considered an indicator of the intelligence of an animal. However, many other factors also affect intelligence and recent discoveries concerning bird intelligence decrease confidence with the usefulness of brain size as an indicator. Since most of the brain is used for maintaining bodily functions, greater ratios of brain to body mass may increase the amount of brain mass available for more complex cognitive tasks. Allometric analysis indicates that mammalian brain size scales at approximately the 2/3 or 3/4 power of the body mass. Comparison of a particular animal's brain size with the expected brain size based on such allometric analysis provides an encephalization quotient (EQ) that can be used as another indication of the animal's intelligence.



Scale model of bottlenose dolphin (*Tursiops truncatus*) brain (middle), compared with brains of wild pig (*Sus scrofa*) (left), and human (*Homo sapiens*) (right).

- Sperm whales (*Physeter macrocephalus*) have the largest brain mass of any extant animal, averaging 7.8 kg in mature males.

- Bottlenose dolphins (*Tursiops truncatus*) have an absolute brain mass of 1500-1700 grams. This is slightly greater than that of humans (1300-1400 grams) and about four times that of chimpanzees (400 grams).
- The brain to body mass ratio (encephalization quotient, or EQ) in some members of the odontocete superfamily Delphinoidea (dolphins, porpoises, belugas, and narwhals) is second only to modern humans, and greater than all other mammals (there is debate whether that of the treeshrew might be second) In some dolphins, it is less than half that of humans: 0.9% versus 2.1%. This comparison seems more favorable if the large amount of blubber (15-20% of mass) that dolphins require for insulation is omitted.
- The encephalization quotient varies widely between species. The Orca/Killer whale has an EQ of 2.57, the franciscana dolphin of 1.67, the Ganges River dolphin of 1.55, the bottlenose dolphin of 4.14, and the tucuxi dolphin of 4.56. These are less than the human EQ of 7.44, but some are greater than that of chimpanzees at 2.49, dogs at 1.17, cats at 1.00, and mice at 0.50.

- One comparative way to try to gauge intelligence is to compare a species' brain size at birth to the completey developed adult brain. This indicates how much learning a species accumulates while young. The majority of mammals are born with a brain close to 90% of the adult weight. Humans are born with 28% of the adult weight, chimpanzees with 54%, bottlenose dolphins with 42.5%, and elephants with 35%. By eighteen months, the brain mass of a bottlenose dolphin is about 80% of that of an adult. Human beings generally do not achieve this percentage until the age of three or four years.

The discovery of spindle cells (neurons without extensive branching, known also as "von Economo neurons", or VENs) in the brains of the humpback whale, fin whale, sperm whale, killer whale, bottlenose dolphins, Risso's dolphins, and beluga whales is another unique discovery. Humans, the great apes, and elephants are the only other species known to have spindle cells, species all well known for their great intelligence. Spindle neurons seem important for development of intelligent behavior. Such a discovery may suggest a convergent evolution of these species. Harkeem *et al's* research of spindle neurons proposes the following theory:

"There are a few mammals apart from hominids, cetaceans, and elephants that have brains somewhat larger than the apes. It would be interesting to determine whether or not these mammals, such as the giraffes and hippopotamuses, have VENs in parts of the brain corresponding to [frontoinsular] and [anterior cingulate cortex]. If they are present, it would suggest that the VEN morphology may be primarily related to absolute brain size. If not, it would suggest that the VENs may be related to behavioral specializations common to hominids, whales, and elephants.

Brain structure

Elephant brains also show a similar complexity to dolphin brains, and are also more convoluted than that of humans, and with a cortex "thicker than that of cetaceans.

However, in dolphins, "no patterns of cellular distribution, nuclear subdivision, or cellular morphology indicate specialization of the LC (coeruleus complex)" despite the large absolute brain size and unihemispheric sleep phenomenology of cetaceans. Moreover, it is generally agreed that the growth of the neocortex, both absolutely and relative to the rest of the brain, during human evolution, has been responsible for the evolution of intelligence, however defined. While a complex neocortex usually indicates great intelligence, there are exceptions to this. For example, the spiny egg laying anteater (echidna) has a very developed brain, yet is not widely considered to be very intelligent.

Some scientists argue that the greater the number of cortical neurons a species has, the greater their intelligence. Although many cetaceans have a great number of cortical neurons, after *Homo sapiens*, the species with the greatest number of cortical neurons and synapses is the elephant. All sleeping mammals, including dolphins, have a stage known as REM sleep. Unlike terrestrial mammals, dolphin brains contain a paralimbic lobe, which may possibly be used for sensory processing. The dolphin is a voluntary breather, even during sleep, with the result that veterinary anaesthesia of dolphins is impossible, as it would result in asphyxiation. Ridgway reports that EEGs show alternating hemispheric asymmetry in slow waves during sleep, with occasional sleep-like waves from both hemispheres. This result has been interpreted to mean that dolphins sleep only one hemisphere of their brain at a time, possibly to control their voluntary respiration system or to be vigilant for predators. This is also given as explanation for the large size of their brains.

Dolphin brain stem transmission time is faster than that normally found in humans, and is approximately equivalent to the speed found in rats. As echo-location is the dolphin's primary means of sensing its environment – analogous to eyes in primates – and since sound travels four and a half times faster in water than in air, scientists speculate that the faster brain stem transmission time, and perhaps the paralimbic lobe as well, assist speedy processing of sound. The dolphin's dependence on speedy sound processing is evident in the structure of its brain: its neural area devoted to visual imaging is only about one-tenth that of the human brain, while the area devoted to acoustical imaging is about 10 times that of the human brain. (This is unsurprising: primate brains devote much more volume to visual processing than those of almost any other animal, and human brains more than other primates.) Sensory experiments suggest a great degree of cross-modal integration in the processing of shapes between echolocative and visual areas of the brain. Unlike the case of the human brain, the cetacean optic chiasm is completely crossed, and there is behavioral evidence for hemispheric dominance for vision.

Problem-solving ability

Some research shows that dolphins among other animals understand concepts such as more or less in term of numerical continuity (but not necessarily counting). A recent research found that dolphins may be able to discriminate between numbers. However, the same researcher suggested that "It may involve mimicry," he said, "as dolphins are unsurpassed in imitative abilities among nonhuman animals."

A commonly used definition of intelligence is "the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience." This definition is separate from social/communicative traits or the ability to learn tricks (which can be done through conditioning), and because of this many people believe that dolphins are not as intelligent as humans.

Several researchers observing animals' ability to learn set formation tend to rank dolphins about the level of elephants in "intelligence" and show that dolphins do not have any unusual talent with problem solving compared with the other animals classed with very great intelligence. Macphail in his "Brain and intelligence in vertebrates" compared data from studies regarding learning "set formation" of animals. The result show that dolphins are skilled at performing this sort of standardized testing but not as adept as other animals of the study. The true extent of dolphin's intelligence is really unknown to humans in the sense that we, ourselves, have evolved over time to maintain sustenance on the land whereas they have evolved to live in the water.

Behavior

Pod characteristics

Dolphin group sizes vary quite dramatically. River dolphins usually congregate in fairly small groups from 6 to 12 in number or, in some species, singly or in pairs. The individuals in these small groups know and recognise one another. Other species such as the oceanic Pantropical Spotted Dolphin, Heaviside's Dolphin and Spinner Dolphin travel in large groups of hundreds of individuals. It is unknown whether every member of the group is acquainted with every other. However, there is no doubt that such large packs can act as a single cohesive unit - observations show that if an unexpected disturbance, such as a shark approach, occurs from the flank or from beneath the group, the group moves in near-unison to avoid the threat. This means that the dolphins must be aware not only of their near neighbors but also of other individuals nearby - in a similar manner to which humans perform "Audience waves". This is achieved by sight, and possibly also echolocation. One speculative hypothesis proposed by Jerison (1986) is that members of a pack of dolphins are able to share echolocation results with each other to create a better understanding of their surroundings.

Resident orcas living in British Columbia, Canada, and Washington, United States live in extremely stable family groups. The basis of this social structure is the matriline, consisting of a mother and her offspring, who travel with her for life. Male orcas never leave their mothers' pods, while female offspring may branch off to form their own matriline if they have many offspring of their own. Males have a particularly strong bond with their mother, and travel with them their entire lives, which can exceed 50 years. It is interesting behavior, as it may seem that there would not be any benefit from this except perhaps in hunting techniques, although they could join other groups to hunt. There are two interesting examples of this familial bond in males. Two male sons, identified as A38 and A39, constantly accompany their mother A30, despite the fact that she does not need protection and they can all hunt by themselves, and rarely leave her side. Researchers have noted that if one son wanders away, one always remains with the mother. Another example are the brothers A32, A37 and A46, whose mother (A36) died. Instead of the family disbanding, the three brothers remain constantly together.

Relationships in the orca population can be discovered through their vocalizations. Matrilines who share a common ancestor from only a few generations back share mostly the same dialect, comprising a pod. Pods who share some calls indicate a common ancestor from many generations back, and make up a clan. Interestingly, the orcas use these dialects to avoid in-breeding. They mate outside the clan, which is determined by the different vocalizations. On one occasion, an orca's mother and father were determined to be of the same clan, although in different pods. There is evidence that other species of dolphins may also have dialects.

In bottlenose dolphin studies by Wells in Sarasota, Florida, and Smolker in Shark Bay, Australia, females of a community are all linked either directly or through a mutual association in an overall social structure known as *fission-fusion*. Groups of the strongest association are known as "bands", and their composition can remain stable over years. There is some genetic evidence that band members may be related, but these bands are not necessarily limited to a single matrilineal line. There is no evidence that bands compete with each other. In the same research areas, as well as in Moray Firth, Scotland, males form strong associations of two to three individuals, with a coefficient of association between 70 and 100. These groups of males are known as "alliances", and members often display synchronous behaviors such as respiration, jumping, and breaching. Alliance composition is stable on the order of tens of years, and may provide a benefit for the acquisition of females for mating. The complex social strategies of marine mammals such as bottlenose dolphins, "provide interesting parallels" with the social strategies of elephants and chimpanzees.

Complex play

Dolphins are known to engage in complex play behavior, which includes such things as producing stable underwater toroidal air-core vortex rings or "bubble rings". There are two main methods of bubble ring production: rapid puffing of a burst of air into the water and allowing it to rise to the surface, forming a ring; or swimming repeatedly in a circle and then stopping to inject air into the helical vortex currents thus formed. The dolphin will often then examine its creation visually and with sonar. They also appear to enjoy biting the vortex-rings they've created, so that they burst into many separate normal bubbles and then rise quickly to the surface. Certain whales are also known to produce bubble rings, or even bubble-nets for the purpose of foraging. Many dolphin species are also known for playing by riding in waves, whether natural waves near the shoreline in a method akin to human "body-surfing", or within the waves induced by the bow of a moving boat in a behavior known as *bow-riding*.

Cross-species cooperation

There have been instances in captivity of various species of dolphin and porpoise helping and interacting across species, including helping beached whales. Also they have been known to live alongside Resident (fish eating) Orca Whales for limited times.

Creative behavior

Aside from having exhibited the ability to learn complex tricks, dolphins have also demonstrated the ability to produce creative responses. This was studied by Karen Pryor during the mid-1960s at Sea Life Park in Hawaii, and was published as "*The Creative Porpoise: Training for Novel Behavior*" during 1969. The two test subjects were two rough-toothed dolphins (*Steno bredanensis*), named Malia (a regular show performer at Sea Life Park) and Hou (a research subject at adjacent Oceanic Institute). The experiment tested when and whether the dolphins would identify that they were being rewarded (by fish) for originality in behavior and was very successful. However, since only two dolphins were involved in the experiment, the study is difficult to generalize.

Starting with the dolphin named Malia, the method of the experiment was to choose a particular behavior exhibited by her each day and reward each display of that behavior throughout the day's session. At the start of each new day Malia would present the prior day's behavior, but only when a new behavior was exhibited was a reward given. All behaviors exhibited were, at least for a time, known behaviors of dolphins. After approximately two weeks Malia apparently exhausted "normal" behaviors and began to repeat performances. This was not rewarded.

According to Pryor the dolphin became almost despondent. However, at the sixteenth session without novel behavior, the researchers were presented with a flip they had never seen before. This was reinforced. As related by Pryor, after the new display: "instead of offering that again she offered a tail swipe we'd never seen; we reinforced that. She began offering us all kinds of behavior that we hadn't seen in such a mad flurry that finally we could hardly choose what to throw fish at..."

The second test subject, Hou, took thirty-three sessions to reach the same stage. On each occasion the experiment was stopped when the variability of dolphin behavior became too complex to make further positive reinforcement meaningful.

The same experiment was repeated with humans, and it took the volunteers about the same length of time to figure out what was being asked of them. After an initial period of frustration or anger, the humans realised they were being rewarded for novel behavior. In dolphins this realisation produced excitement and more and more novel behaviors - in humans it mostly just produced relief.

Captive orcas have often displayed interesting responses when they get 'bored' with activities. For instance, when Dr. Paul Spong worked with the orca Skana, he researched her visual skills. However, after performing favorably in the 72 trials per day, Skana suddenly began consistently getting every answer wrong. Dr Spong concluded that a few fish were not enough motivation. He began playing music, which seemed to provide Skana with much more motivation.

At the Institute for Marine Mammal Studies in Mississippi, it has also been observed that the resident dolphins seem to show an awareness of the future. The dolphins are trained to keep their own tank clean by retrieving rubbish and bringing it to a keeper, to be rewarded with a fish. However, one dolphin, named Kelly, has apparently learned a way to get more fish, by hoarding the trash under a rock at the bottom of the pool and bringing it up one small piece at a time.

Use of tools

As of 2005, scientists have observed limited groups of bottlenose dolphins around the Australian Pacific using a basic tool. When searching for food on the sea floor, many of these dolphins were seen tearing off pieces of sponge and wrapping them around their "bottle nose" to prevent abrasions.

Communication

Whale song is the sounds made by whales and which is used for different kinds of communication.

Dolphins emit two distinct kinds of acoustic signals, which are named *whistles* and *clicks*.

- Clicks - quick broadband burst pulses - are used for echolocation, although some lower-frequency broadband vocalizations may serve a non-echolocative purpose such as communication; for example, the pulsed calls of Orcas. Pulses in a click train are emitted at intervals of ~35-50 milliseconds, and in general these inter-click intervals are slightly greater than the round-trip time of sound to the target.
- Whistles - narrow-band frequency modulated (FM) signals - are used for communicative purposes, such as contact calls, the pod-specific dialects of resident Orcas, or the signature whistle of bottlenose dolphins.

There is strong evidence that some specific whistles, named *signature whistles*, are used by dolphins to identify and/or call each other; dolphins have been observed emitting both other specimens' signature whistles, and their own. A unique signature whistle develops quite early during a dolphin's life, and it appears to be created in an imitation of the signature whistle of the dolphin's mother.

Xitco reported the ability of dolphins to eavesdrop passively on the active echolocative inspection of an object by another dolphin. Herman terms this effect the "acoustic flashlight" hypothesis, and may be related to findings by both Herman and Xitco on the comprehension of variations on the pointing gesture, including human pointing, dolphin postural pointing, and human gaze, in the sense of a redirection of another individual's attention, an ability which may require theory of mind.

The environment where dolphins live makes experiments much more expensive and complicated than for many other species; additionally, the fact that cetaceans can emit and hear sounds (which are believed to be their main means of communication) in a range of frequencies much wider than that of humans means that sophisticated equipment, which was scarcely available in the past, is needed to record and analyse them. For example, clicks can contain significant energy in frequencies greater than 110 kHz (for comparison, it is unusual for a human to be able to hear sounds above 20 kHz), requiring that equipment have a sampling rates of at least 220 kHz; MHz-capable hardware is often used.

In addition to the acoustic communication channel, the visual modality is also significant. The contrasting pigmentation of the body may be used, for example with "flashes" of the hypopigmented ventral area of some species, as can the production of bubble streams during signature whistling. Also, much of the synchronous and cooperative behaviors, as described in the Behavior section of this entry, as well as cooperative foraging methods, likely are managed at least partly by visual means.

While there is little evidence for dolphin language, experiments have shown that they can learn human sign language. Akeakamai, a bottlenose dolphin, was able to understand both individual words and basic sentences like "touch the frisbee with your tail and then jump over it" (Herman, Richards, & Wolz 1984). Dolphins have also exhibited the ability to understand the significance of the ordering of each set of tasks in one sentence.

Self-awareness

Self-awareness is seen, by some, to be a sign of very-developed, abstract thinking. Self-awareness, though not well-defined scientifically, is believed to be the precursor to more advanced processes like meta-cognitive reasoning (thinking about thinking) that are typical of humans. Scientific research of this topic has suggested that bottlenose dolphins, along side elephants and great apes possess self-awareness.

The most widely used test for self-awareness in animals is the mirror test, developed by Gordon Gallup during the 1970s, in which a temporary dye is placed on an animal's body, and the animal is then presented with a mirror. Some scientists still disagree with these findings, arguing that the results of these tests are open to human interpretation and susceptible to the Clever Hans effect. This test is much less definitive than when used for primates, because primates can touch the mark or the mirror, while dolphins cannot, making their alleged self-recognition behavior less certain. Critics argue that behaviors that are said to identify self-awareness resemble existing social behaviors, and so researchers could be misinterpreting social responses to another dolphin. The researchers counter-argue that the behaviors shown to evidence self-awareness are very different from normal responses to another dolphin, including paying significantly more attention to another dolphin than towards their mirror image. Dr. Gallup termed the results "*the most suggestive evidence to date*" of mirror self-recognition in dolphins, but "*not definitive*" because he was not certain that the dolphins were not interpreting the image in the mirror as another animal. Whereas apes can merely touch the mark on themselves with their fingers, dolphins show less definitive behavior of self-awareness, twisting and turning themselves to observe the mark.

As a further response to these criticisms, during 1995, Marten and Psarakos used television to test dolphin self-awareness. They showed dolphins real-time footage of themselves, recorded footage, and another dolphin. They concluded that their evidence suggested self-awareness rather than social behavior. However, this study has not been repeated since then, the results remain thus uncorroborated. However, dolphins have since passed the mirror test. (Reiss,Marino)

Comparative cognition

Research of the comparative cognition of the dolphin is one of the primary methods of the investigation of cetacean intelligence.

Examples of cognitive abilities investigated in the dolphin include concept formation, sensory skills, and the use of mental representation of dolphins. Such research has been ongoing since the late 1970s, and includes the specific topics of: acoustic mimicry, behavioral mimicry (inter- and intra-specific), comprehension of novel sequences in an artificial language (including non-finite state grammars as well as novel anomalous sequences), memory, monitoring of self-behaviors (including reporting on these, as well as avoiding or repeating them), reporting on the presence and absence of objects, object categorization, discrimination and matching (identity matching to sample, delayed matching to sample, arbitrary matching to sample, matching across echolocation and vision, reporting that no identity match exists, etc.), synchronous creative behaviors between two animals, comprehension of symbols for various body parts, comprehension of the pointing gesture and gaze (as made by dolphins or humans), problem solving, echolocative eavesdropping, and more. Some researchers include Louis Herman, Mark Xitco, John Gory, Stan Kuczaj, Adam Pack, and many others.

While these are largely laboratory studies, field studies relating to dolphin and cetacean cognition are also relevant to the issue of intelligence, including those proposing tool use, culture, fission-fusion social structure (including tracking alliances and other cooperative behavior), acoustic behavior (bottlenose dolphin signature whistles, sperm whale clicks, orca pod vocalizations), foraging methods (partial beaching, cooperation with human fishermen, herding fish into a ball, etc.). See: Richard Connor, Hal Whitehead, Peter Tyack, Janet Mann, Randall Wells, Kenneth Norris, B. Wursig, John Ford, Louis Herman, Diana Reiss, Lori Marino, Sam Ridgway, Paul Nachtigall, Eduardo Mercado, Denise Herzing, Whitlow Au.

In contrast to the primates, cetaceans are particularly far-removed from humans in evolutionary time. Therefore, cognitive abilities generally cannot be claimed to derive from a common ancestor, whereas such claims are sometimes made by researchers studying primate cognition. Though cetaceans and humans (in common with all mammals) had a common ancestor in the distant past, it was almost certainly of distinctly inferior cognitive abilities compared to its modern descendants. The early divergence of the human—dolphin ancestry line creates a problem in what cognitive tasks to test for because human/dolphin brains have been naturally selected so differently, with completely different cognitive abilities favoring their very different environments. Therefore, an anthropomorphic problem exists with exactly what cognitive abilities to test, how to test them, as well as the validity of the experimental results because of the completely different evolutionary lineage and environment human and cetaceans have.

Chapter 8

Dog Intelligence

Many dogs can easily be trained to retrieve objects like this stick.

Dog intelligence is the ability of a dog to learn, think, and solve problems. Dog trainers, owners, and researchers have as much difficulty agreeing on a method for testing canine intelligence as they do for human intelligence. One specific difficulty is confusing a breed's genetic characteristics and a dog's obedience training with intelligence.

Certain breeds, like Doberman Pinschers, Border Collies, Poodles, German Shepherds, Shetland Sheepdogs, Rottweilers, Labrador Retrievers, Papillons, Australian Cattle Dogs and Golden Retrievers, are claimed by some to be "smarter" breeds of dogs because of their obedience. However, the ability and willingness to learn and obey commands is not the only possible measurement of intelligence. Other breeds, such as sled dogs and sight hounds demonstrate intelligence in other ways.

Inherited abilities

Dogs are pack animals. They understand social structure and obligations, and are capable of interacting with other members of the pack. Adult canines train their young by "correcting" them when they behave in an unacceptable manner (such as biting too hard or eating out of turn) and reward them for acceptable behavior, by playing with them, feeding them, or cleaning them.

They are also den animals. This means that they can easily learn behavior related to keeping the den clean (such as housebreaking) and relaxing in an enclosed area (such as a crate during travel or for training).

Some breeds have been selectively bred for hundreds or thousands of years for the quality of learning quickly. That quality has been downplayed for other breeds in favor of other characteristics like the ability to track or hunt game, or to fight other animals. The capacity to learn basic obedience and complicated behavior, however, is inherent in all dogs. Owners must simply be more patient with some breeds than with others.

Nonetheless, inherited behavior is not necessarily an indicator of intelligence. For example, a sheep herding breed, like a Border Collie, would be expected to learn how to herd sheep very quickly and might even perform the job with little training. The same breed, however, would be a challenge to train how to point and retrieve game. A Pointer often points to game instinctively and naturally retrieves game without damaging it, but training it to herd sheep would be difficult if not impossible.

Evaluation of intelligence

The meaning of "intelligence" in general, not only in reference to dogs, is hard to define. Some tests measure problem-solving abilities and others test the ability to learn in comparison to others of the same age. Defining it for dogs is just as difficult. It is likely that dogs do not have the ability to premeditate an action to solve a problem. Some dogs may, however, have more drive to keep trying various things until they accidentally reach a solution and still others might have more ability to make the association between the "accident" and the result.

For example, the ability to learn quickly could be a sign of intelligence. It could be interpreted as a sign of blind subservience and a desire to please. In contrast, some dogs who do not learn very quickly may have other talents. An example is breeds that are not particularly interested in pleasing their owners, such as Siberian Huskies. Huskies are often fascinated with the myriad possibilities for escaping from yards and catching small animals, figuring out on their own numerous and often ingenious ways of doing both.

Assistance dogs are also required to be obedient at all times. This means they must learn a tremendous number of commands, understand how to act in a large variety of situations, and recognize threats to their human companions, some of which they might never before have encountered.

Many owners of livestock guardian breeds believe that breeds such as Great Pyrenees or the Kuvasz are not easily trained because their independent nature prevents them from seeing the point of such commands as "sit" or "down". The Molosser breeds are said to be particularly sensitive to physical or vocal aggression and, as such, are generally thought to respond to positive reinforcement-based methods of training. Hounds, (such as Beagles, Bloodhounds, and Basset Hounds), rank in the bottom tier of "The Intelligence of Dogs" list, but probably suffer from a certain approach to intelligence assessment. These dogs are bred to have a tenacious tracking mentality, taking advantage of their acute sense of smell, and less ability in "problem solving," which is the central task of Working and Herding dogs. In addition, many dog "authorities" are unaware of the Scenthound's extraordinary ability to perceive and evaluate things other than odors. They can detect pheromones, among other things, and may have the ability to evaluate a human's or another dog's personality or disposition from as far away as 300 feet. This can be described as "conditional intelligence" where the animal is quick to learn some things, while appearing reluctant to learn others.

Testing and research

Certain intelligence tests involve the dog's ability to recognize and respond to a large vocabulary of commands. Other tests involve their desire or ability to respond to different situations. Just as with humans, there is a wide variety of interpretations as to what makes a dog "intelligent".

Various studies have attempted to rigorously classify intelligence of dogs. A recent example is animal psychologist Juliane Kaminski's paper in *Science* that demonstrated that Rico, a Border Collie, could learn over 200 words. Rico could remember the names of several items for up to four weeks after its last exposure (Kaminski eliminated the Clever Hans effect using strict protocols). Rico was also able to interpret phrases such as "fetch the sock" in terms of its component words (rather than considering its utterance to be a single word). Rico could also give the sock to a specified person. In 2008, Betsy, also a Border Collie, was featured on the cover of National Geographic Magazine. Betsy's intelligence rivaled that of Rico's in that she knew over 340 words and was able to correlate an object with a photographic image of the object, despite having seen neither before.

In his 1996 book *Good Natured*, ethologist Frans de Waal discusses an experiment on guilt and reprimands conducted on a female Siberian husky. The dog had the habit of shredding newspapers, and when her owner returned home to find the shredded papers and scold her she would act guilty. However, when the owner himself shredded the papers without the dog's knowledge, the dog "acted just as 'guilty' as when she herself had created the mess." De Waal concludes that the "guilt" displayed by dogs is not true guilt but rather the anticipation of the behavior of an angry superior in a given situation.

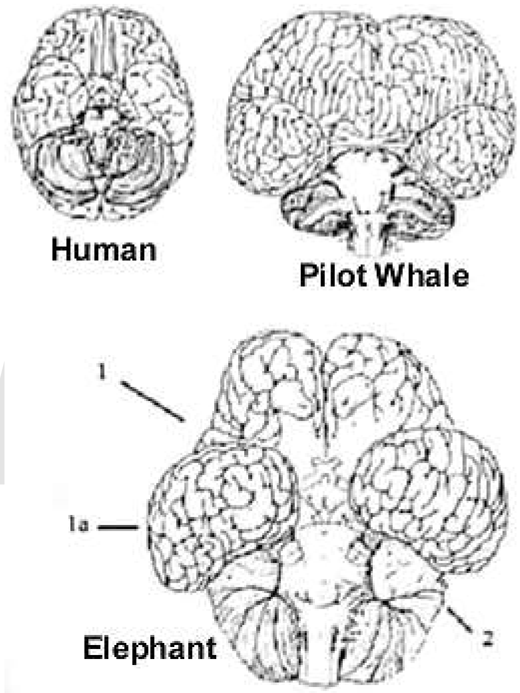
A recent study in the journal PNAS concluded that dogs can feel complex emotions, like jealousy.

Psychology research has shown that human faces are asymmetrical with the gaze instinctively moving to the right side of a face upon encountering other humans to obtain information about their emotions and state. Research at the University of Lincoln (2008) shows that dogs share this instinct when meeting a human being, and only when meeting a human being (i.e., not other animals or other dogs). As such they are the only non-primate species known to do so.

School psychologist Kathy Coon developed the first intelligence test for dogs in 1976 , with the work continuously revised through 2003. Assessments were developed to test short term memory, agility, ability to adapt, problem solving, unique detour problems, and to see how the dog reacts to conditions which he or she finds unacceptable. The performance of individual dogs was compared to over 100 dogs on which the test was standardized. Additional breed norms were developed in her book, *The Dog Intelligence Test*.

Chapter 9

Elephant Intelligence



Human, pilot whale and elephant brains up to scale. (1)-cerebrum (1a)-temporal lobe and (2)-cerebellum

Elephants are amongst the world's most intelligent species. With a mass of just over 5 kg (11 lb), elephant brains are larger than those of any other land animal, and although the largest whales have body masses twenty-fold those of a typical elephant, whale brains are barely twice the mass of an elephant's brain. The elephant's brain is similar to that of humans in terms of structure and complexity - such as the elephant's cortex having as many neurons as a human brain, suggesting convergent evolution.

Elephants exhibit a wide variety of behaviors, including those associated with grief, learning, allomothering, mimicry, art, play, a sense of humor, altruism, use of tools, compassion, cooperation, self-awareness, memory and possibly language. All point to a highly intelligent species that are thought to be equal with cetaceans and primates. Due to the high intelligence and strong family ties of elephants, some researchers argue it is morally wrong for humans to cull them.

Aristotle once said that elephants were "The beast which passeth all others in wit and mind."

Brain structure

Cerebral cortex

The elephant (both Asian and African) has a very large and highly convoluted neocortex, a trait also shared by humans, apes and certain dolphin species. Scientists see this as a sign of complex intelligence. While this is the widely held belief, there is at least one exception: the echidna has a highly developed brain, yet is not considered to be intelligent. Asian elephants have the greatest volume of cerebral cortex available for cognitive processing of all existing land animals. Elephants have a volume of cerebral cortex available for cognitive processing that exceeds that of any primate species, and extensive studies place elephants in the category of great apes in terms of cognitive abilities for tool use and tool making.

The elephant brain exhibits a gyral pattern more complex and with more numerous convolutes, or brain folds, than that of humans,primates or carnivores, but less complex than cetaceans. However, the cortex of the elephant brain is "thicker than that of cetaceans" and is believed to have as many cortical neurons (nerve cells) and cortical synapses as that of humans, which exceeds that of cetaceans. Elephants are believed to rank equal with dolphins in terms of problem-solving abilities, and many scientists tend to rank elephant intelligence at the same level as cetaceans; in fact, a 2011 article published by ABC Science states that, "elephants [are as] smart as chimps, [and] dolphins".

Other features of the brain

Elephants also have a very large and highly convoluted hippocampus, a brain structure in the limbic system that is much bigger than that of any human, primate or cetacean. The hippocampus of an elephant takes up about 0.7% of the central structures of the brain, comparable to 0.5% for humans and with 0.1% in Risso's dolphins and 0.05% in bottlenose dolphins. The hippocampus is linked to emotion through the processing of certain types of memory, especially spacial. This is thought possibly to be why elephants suffer from psychological flashbacks and the equivalent of post-traumatic stress disorder (PTSD).

The encephalization quotient (EQ) of elephants "ranges from 1.13 to 2.36. The total EQ average is 1.88, with an average of 2.14 for Asian elephants, and 1.67 for African, There is considerable debate about whether the EQ, or size of the brain relative to body size, is an accurate gauge for intelligence, especially since the animal with the highest EQ is a treeshrew yet they are not considered to be highly intelligent.

Brain size at birth relative to adult brain size

Like humans, elephants must learn behavior as they grow up. They are not born with the instincts of how to survive. Elephants have a very long period in their lives for learning, lasting for around ten years. One comparative way to try to gauge intelligence is to compare brain size at birth to the fully developed adult brain. This indicates how much learning a species accumulates while young. The majority of mammals are born with a brain close to 90% of the adult weight.

Humans are born with 28% of the adult weight, bottlenose dolphins with 42.5%, chimpanzees with 54%, and elephants with 35%. This indicates that elephants have the highest amount of learning to undergo next to humans, and behavior is not mere instinct but must be taught throughout life. It should be noted that instinct is quite different from learned intelligence. Parents will teach their young how to feed, use tools and learn their place in the highly complex elephant society. The cerebrum temporal lobes, which function as storage of memory, are much larger than those of a human.

Spindle neurons

Spindle cells appear to play a central role in the development of intelligent behavior. Initially, it was thought that the presence of spindle neurons was unique to humans and the great apes. However, studies have shown that spindle neurons are also found in the brains of both Asian and African elephants, as well as humpback whales, fin whales, killer whales, sperm whales, bottlenose dolphins, Risso's dolphins, and beluga whales. The remarkable similarity between the elephant brain and the human brain supports the thesis of convergent evolution.

Elephant society

The elephant has one of the most closely knit societies of any living species. Elephant families can only be separated by death or capture. Cynthia Moss, an ethologist specialising in elephants, recalls an event involving a family of African elephants. Two members of the family were shot by poachers, who were subsequently chased off by the remaining elephants. Although one of the elephants died, the other, named Tina, remained standing, but with knees beginning to give way. Two family members, Trista and Teresia (Tina's mother), walked to both sides of Tina and leaned in to hold her up. Eventually, Tina grew so weak, she fell to the ground and died. However, Trista and Teresia did not give up but continually tried to lift her. They managed to get Tina into a sitting position, but her body was lifeless and fell to the ground again. As the other elephant family members became more intensely involved in the aid, they tried to put grass into Tina's mouth. Teresia then put her tusks beneath Tina's head and front quarters and proceeded to lift her. As she did so, her right tusk broke completely off, right up to the lip and nerve cavity. The elephants gave up trying to lift Tina but did not leave her;

instead, they began to bury her in a shallow grave and throw leaves over her body. They stood over Tina for the night and then began to leave in the morning. The last to leave was Teresia.

Because elephants are so closely knit and highly matriarchal, a family can be devastated by the death of another (especially a matriarch), and some groups never recover their organization. Cynthia Moss has observed a mother, after the death of her calf, walk sluggishly at the back of a family for many days.

Edward Topsell stated in his publication *The History of Four-Footed Beasts* in 1658, "There is no creature among all the Beasts of the world which hath so great and ample demonstration of the power and wisdom of almighty God as the elephant." Of note, he stated in the same publication that elephants worship the sun and the moon and become pregnant by chewing on mandrake, neither of which are true. Elephants are believed to be on par with chimpanzees with regards to their cooperative skills.

Elephant altruism

Elephants are thought to be highly altruistic animals that will even aid other species, including humans, in distress. In India, an elephant was helping locals lift logs by following a truck and placing the logs in pre-dug holes upon instruction from the mahout (elephant trainer). At a certain hole, the elephant refused to lower the log. The mahout came to investigate the hold-up and noticed a dog sleeping in the hole. The elephant only lowered the log when the dog was gone.

Cynthia Moss has often seen elephants going out of their way to avoid hurting or killing a human, even when it was difficult for them (such as having to walk backwards to avoid a person).

Joyce Poole documented an encounter told to her by Colin Francombe on Kuki Gallman's Laikipia Ranch. A ranch herder was out on his own with camels when he came across a family of elephants. The matriarch charged at him and knocked him over with her trunk, breaking one of his legs. In the evening, when he did not return, a search party was sent in a truck to find him. When the party discovered him, he was being guarded by an elephant. The animal charged the truck, so they shot over her and scared her away. The herdsman later told them that when he could not stand up, the elephant used her trunk to lift him under the shade of a tree. She guarded him for the day and would gently touch him with her trunk.

Self-medication

Elephants in Africa will self-medicate by chewing on the leaves of a tree from the Boraginaceae family, which induces labor. Kenyans also use this tree for the same purpose.

Death ritual

Elephants are the only species on Earth other than *Homo sapiens sapiens* and Neanderthals known to have or have had any recognizable ritual around death. They show a keen interest in the bones of their own kind (even unrelated elephants that have died long ago). They are often seen gently investigating the bones with their trunks and feet and remaining very quiet. Sometimes elephants that are completely unrelated to the deceased will still visit their graves. When an elephant is hurt, other elephants (even if they are unrelated) will aid them.

Elephant researcher Martin Meredith recalls an occurrence in his book about a typical elephant death ritual that was witnessed by Anthony Michael Hall, a South African biologist who had studied elephants in Addo, South Africa, for over eight years. The entire family of a dead matriarch, including her young calf, were all gently touching her body with their trunks, trying to lift her. The elephant herd were all rumbling loudly. The calf was observed to be weeping and made sounds that sounded like a scream, but then the entire herd fell incredibly silent. They then began to throw leaves and dirt over the body and broke off tree branches to cover her. They spent the next two days quietly standing over her body. They sometimes had to leave to get water or food, but they would always return.

Occurrences of elephants behaving this way around human beings are common throughout Africa. On many occasions, they have buried dead or sleeping humans or aided them when they were hurt. Meredith also recalls an event told to him by George Adamson, a Kenyan Game Warden, regarding an old Turkana woman who fell asleep under a tree after losing her way home. When she woke up, there was an elephant standing over her, gently touching her. She kept very still, because she was very frightened. As other elephants arrived, they began to scream loudly and buried her under branches. She was found the next morning by the local herdsmen, unharmed.

George Adamson also recalls when he shot a bull elephant from a herd that kept breaking into the government gardens of Northern Kenya. George gave the elephant's meat to local Turkana tribesmen and then dragged the rest of the carcass half a mile away. That night, the other elephants found the body and took the shoulder blade and leg bone and returned the bones to the exact spot the elephant was killed. Scientists often debate the extent that elephants feel emotion.

Play

Joyce Poole on many occasions has observed wild African elephants at play. They apparently do things for their own and others' entertainment. Elephants have been seen sucking up water, holding their trunk high in the air, and then spraying the water like a fountain.

Mimicry

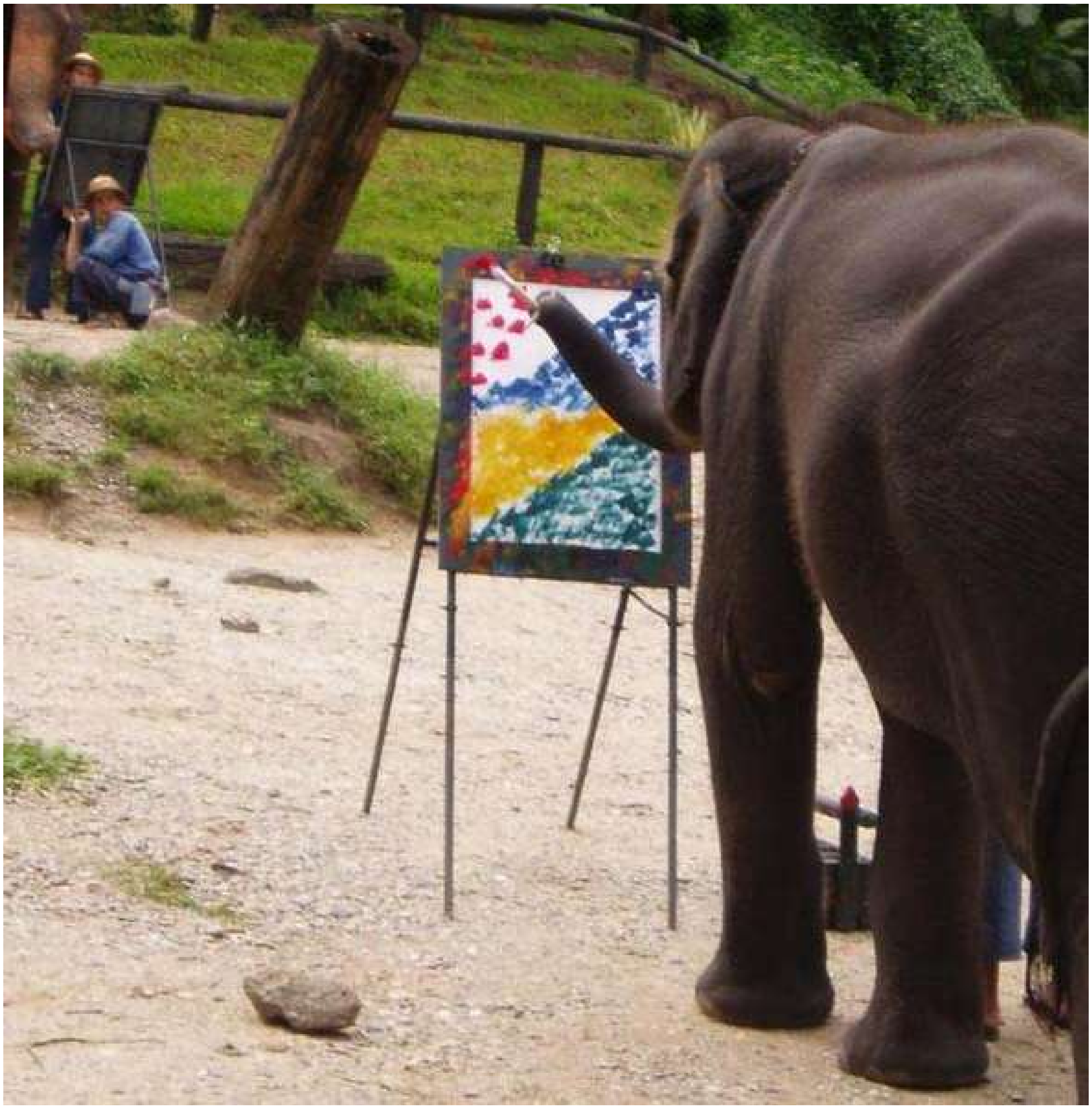
Recent studies have shown that elephants can also mimic sounds they hear. The discovery was found when Mlaika, an orphaned elephant, would copy the sound of trucks passing by. So far, the only other animals that are thought to mimic sounds are whales, dolphins, bats, primates and birds. Calimero, an African elephant who was 23 years old, also exhibited a unique form of mimicry. He was in a Swiss zoo with some Asian elephants. Asian elephants use chirps that are different from African elephants' deep rumbling noises. Calimero also began to chirp and not make the deep calls that his species normally would.

Kosik, an Indian elephant at Everland Amusement Park, South Korea, surprised trainers when they thought there was a person in his enclosure that was actually Kosik imitating Jong Gap Kim, his trainer. Kosik can make sounds imitating up to eight Korean words, including *sit*, *no*, *yes* and *lie down*. His mimicry is remarkably human-sounding. Kosik produces human-like sounds by putting his trunk in his mouth and then shaking it while breathing out, similar to how people whistle with their fingers. Elephants use contact calls to stay in touch with one another when they are out of one another's sight. Female elephants are able to remember and distinguish the contact calls of female family and bond group members from those of females outside of their extended family network. They can also distinguish between the calls of family units depending upon how frequently they came across them.

Tool use

Elephants show a remarkable ability to use tools, using their trunks like arms. Elephants have been observed digging holes to drink water and then ripping bark from a tree, chewing it into the shape of a ball, filling in the hole and covering over it with sand to avoid evaporation, then later going back to the spot for a drink. They also often use branches to swat flies or scratch themselves. Elephants have also been known to drop very large rocks onto an electric fence either to ruin the fence or to cut off the electricity.

Art



A painting elephant

Like several other species, elephants are able to produce abstract art using their trunks to hold brushes. An example of this was shown in the TV program *Extraordinary Animals*, in which elephants at a camp in Thailand were able to draw self-portraits with flowers. Although the images were drawn by the elephants, there was always a person assisting and guiding the movement. From those presentations, it cannot be definitely evaluated whether the elephants are conscious about the shape of their drawings or not.

This extraordinary video documentation of an elephant painting a picture of an elephant - possibly indicating self-awareness - has become widespread on internet news and video websites. The quality of the painting is extremely high, leading many astonished viewers to doubt the video's authenticity.

Problem-solving ability

Elephants are able to spend a lot of time working on problems. They are able to change their behavior radically to face new challenges, a hallmark of complex intelligence. A 2010 experiment revealed that in order to reach food, "elephants can learn to coordinate with a partner in a task requiring two individuals to simultaneously pull two ends of the same rope to obtain a reward", putting them on an equal footing with chimpanzees in terms of their level of cooperative skills.

In the 1970s, at Marine World Africa, USA, there lived an Asian elephant named Bandula. Bandula worked out how to break open or unlock several of the pieces of equipment used to keep the shackles on her feet secure. The most complex device was a brommel hook, a device that closes when two opposite points are slid together. Bandula used to fiddle with the hook until it slid apart when it was aligned. Once she had freed herself, she would help the other elephants escape. In Bandula's case and certainly with other captive elephants, there was an element of deception involved during the escapes, such as the animals looking around making sure no one was watching.

In another case, a female elephant worked out how she could unscrew iron rods with an eye hole that were an inch thick. She used her trunk to create leverage and then untwist the bolt.

Ruby, an Asian elephant at Phoenix Zoo would often eavesdrop on conversations keepers would have talking about her. When she heard the word *paint*, she became very excitable. The colours she favoured were green, yellow, blue and red. On one particular day, there was a fire truck that came and parked outside her enclosure where a man had just had a heart attack. The lights on the truck were flashing red, white and yellow. When Ruby painted later on in the day, she chose those colours. She also showed a preference for particular colours that the keepers wore.

Harry Peachey, an elephant trainer, developed a cooperative relationship with an elephant named Koko. Koko would help out the keepers, "prompting" the keepers to encourage him with various commands and words that Koko would learn. Peachey stated that elephants are almost predisposed to cooperate and work with humans as long as they are treated with respect and sensitivity. Koko worked out when his keepers needed a bit of "elephant help" when they were transferring the females of the group to another zoo. When the keepers wanted to transfer a female, they would usually say her name, followed by the word *transfer* (e.g., "Connie transfer"). Koko soon figured out what this meant. If the keepers asked an elephant to transfer and they did not budge, they would say, "Koko, give me a hand." When he heard this, Koko would help. Peachey firmly believes that after 27 years of working with elephants, they can understand the semantics and syntax of some of the words they hear. This is something thought to be very rare in the animal kingdom.

A study by Dr. Naoko Irie of Tokyo University has shown that elephants demonstrate skills at arithmetic. The experiment "consist[ed] of dropping varying numbers of apples into two buckets in front of the [Ueno Zoo] elephants and then recording how often they could correctly choose the bucket holding the most fruit." When more than one apple was being dropped into the bucket, this meant that the elephants had to "keep running totals in their heads to keep track of the count." The results showed that "Seventy-four percent of the time, the animals correctly picked the fullest bucket. An African elephant named Ashya scored the highest with an amazing eighty-seven percent…. Humans in this same contest managed a success rate of just sixty-seven percent." The study was also filmed to ensure its accuracy.

Self-awareness

Asian Elephants have joined a small group of animals, including great apes, bottlenose dolphins and magpies, that exhibit self-awareness. The study was conducted with the Wildlife Conservation Society (WCS) using elephants at the Bronx Zoo in New York. Although many animals will respond to a mirror, very few show any evidence that they recognize it is in fact themselves in the mirror reflection.

The Asian elephants in the study also displayed this type of behavior when standing in front of a 2.5 m-by-2.5 m mirror - they inspected the rear and brought food close to the mirror for consumption.

Evidence of elephant self awareness was shown when the elephant Happy repeatedly touched a painted *X* on her head with her trunk, a mark which could only be seen in the mirror. Happy ignored another mark made with colourless paint that was also on her forehead to ensure she was not merely reacting to a smell or feeling.

Frans De Waal, who ran the study, stated, "These parallels between humans and elephants suggest a convergent cognitive evolution possibly related to complex society and cooperation."

Joyce Poole, of the Amboseli Elephant Research Project, Kenya, has demonstrated vocal learning and imitation in elephants of sounds made by each other and in the environment. She is beginning to research whether sounds made by elephants have dialects, a trait that is rare in the animal kingdom.

Self-awareness and culling

There has been considerable debate over the issue of culling African elephants in South Africa's Kruger National Park as a means of controlling the population. Some scientists and environmentalists argue that it is "unnecessary and inhumane" to cull them since "elephants resemble humans in a number of ways, not least by having massive brains, social bonds that appear to be empathetic, long gestations, high intelligence, offspring that require an extended period of dependent care, and long life spans. A South African Animal Rights group asked in a statement anticipating the announcement, 'How much like us do elephants have to be before killing them becomes murder?'". Others argue that culling is necessary when biodiversity is threatened.

Chapter 10

Great Ape Language

Research into non-human **great ape language** has involved teaching chimpanzees, gorillas and orangutans to communicate with human beings and with each other using sign language, physical tokens, and lexigrams. Some primatologists argue that the primates' use of these tools indicates their ability to use "language", although this is not consistent with some definitions of that term.

Questions in animal language research

Animal language research attempts to answer the following questions:

- What problems can animals solve without language, and can they solve them better after they have received language training?
- Can the lessons learned in teaching animals be applied to human children?
- How, and how much, do animals' abilities to learn language differ from those of humans?
- Are the abilities that underlie language general or highly specialized?
- Where is the line between language and other forms of communication?

Apes that demonstrate understanding

Non-human animals have been recorded to have produced behaviors that are consistent with meanings accorded to human sentence productions. (A *production* is a stream of *lexemes* with semantic content. A language is grammar and a set of lexemes. A *sentence*, or statement, is a stream of lexemes that obeys a grammar, with a beginning and an end.) Some animals in the following species can be said to "understand" (*receive*), and some can "apply" (*produce*) consistent, appropriate, grammatical streams of communication. David Premack and Jacques Vauclair have cited language research for the following animals:

- Common Chimpanzees and Bonobos
- Gorillas

- Orangutans

Primate use of sign language

Sign language and computer keyboards are used in primate language research because non-human primates lack vocal cords and other human speech organs. However, primates do possess the manual dexterity required for keyboard operation.

Many researchers into animal language have presented the results of the studies described below as evidence of linguistic abilities in animals. Many of their conclusions have been disputed.

It is now generally accepted that Apes can learn to sign and are able to communicate with humans. However, it is disputed as to whether they can form syntax to manipulate such signs.

Washoe

Washoe, a Common Chimpanzee, was caught in the wild in 1966. When she was about ten months old, she was received by the husband-and-wife research team of Beatrix T. Gardner and R. Allen Gardner. Chimpanzees are completely dependent until two years of age and semi-dependent until the age of four. Full adult growth is reached between 12 and 16 years of age. So the Gardners received her at a good age for research into language development. The Gardners tried to make Washoe's environment as similar as possible to what a human infant with deaf parents would experience. There was always a researcher or assistant in attendance during Washoe's waking hours. Every researcher communicated with Washoe by using American Sign Language (ASL), minimizing the use of the spoken voice. The researchers acted as friends and companions to Washoe, using various games to make the learning as exciting as possible.

The Gardners used many different training methods:

- *Imitation:* After Washoe had learned a couple of words, she started, like chimpanzees usually do, to imitate naturally. For example, when she entered the Gardners' bathroom, she spontaneously made the sign for "toothbrush", simply because she saw one.
- *Babbling:* In this case, "babbling" does not mean vocal babbling. Instead, Washoe used untaught signs to express a desire. She used a begging gesture, which was not much different from the ASL signs "give me" and "come." (Human infants who are learning sign language often babble with their hands.)
- *Instrumental Conditioning:* The researchers used instrumental conditioning strategies with Washoe. For example, they taught the word "more" by using tickling as a reward. This technique was later applied to a variety of relevant situations.

The results of the Gardners' efforts were as follows:

- *Vocabulary:* When a sign was reported by three independent observers, it was added to a checklist. The sign had to occur in an appropriate context and without prompting. The checklist was used to record the frequency of a sign. A sign had to be used at least once a day for 15 consecutive days before it was deemed to have been acquired. Alternatively, a sign had to be used at least 15 days out of 30 consecutive days. By the end of the 22nd month of the project, thirty-four signs had been learned.
- *Differentiation:* Washoe used the sign "more" in many different situations until a more specific sign had been learned. At one point, she used the sign for "flower" to express the idea of "smell." After additional training, Washoe was eventually able to differentiate between "smell" and "flower."
- *Transfer:* Although the same object was presented for each learning trial (a specific hat, for example), Washoe was able to use the sign for other similar objects (e.g. other hats).
- *Combinations:* Washoe was able to combine two or three signs in an original way. For example, "open food drink" meant "open the fridge" and "please open hurry" meant "please open it quickly."

Nim Chimpsky

Linguistic critics challenged the animal trainers to demonstrate that Washoe was actually using language and not symbols. The *null hypothesis* was that the Gardners were using conditioning to teach the chimpanzee to use hand formations in certain contexts to create desirable outcomes, and that they had not learned the same linguistic rules that humans innately learn.

In response to this challenge, the chimpanzee Nim Chimpsky was taught to communicate using sign language in studies led by Herbert S. Terrace. In 44 months Nim Chimpsky learned 125 signs. However, linguistic analysis of Nim's communications demonstrated that Nim's use was symbolic, and lacked grammar, or rules, of the kind that humans use in communicating via language. This constitutes a chimpanzee vocabulary learning rate of roughly 0.1 words per day. This rate is not comparable to the average college-educated English-speaking human who learns roughly 14 words per day between ages 2 and 22.

Plastic tokens

Sarah and two other chimpanzees, Elizabeth and Peony, in the research programs of David Premack, demonstrated the ability to produce grammatical streams of token selections. The selections came from a vocabulary of several dozen plastic tokens; it took each of the chimpanzees hundreds of trials to reliably associate a token with a referent, such as an apple or banana. The tokens were chosen to be completely different in appearance from the referents. After learning these protocols, Sarah was then able to associate other tokens with consistent behaviors, such as negation, name-of, and if-then. The plastic tokens were placed on a magnetic slate, within a rectangular frame in a line. The tokens had to be selected and placed in a consistent order (a grammar) in order for the trainers to reward the chimpanzees.

One other chimpanzee, Gussie, was trained along with Sarah but failed to learn a single word. Other chimpanzees in the projects were not trained in the use of the tokens. All nine of the chimpanzees could understand gestures, such as supplication when asking for food; similarly, all nine could point to indicate some object, a gesture which is not seen in the wild. The supplication is seen in the wild, as a form of communication with other chimpanzees.

A juvenile Sumatran orangutan Aazk (named after the American Association of Zookeepers) who lived at the Roeding Park Zoo (Fresno, California) was taught by Gary L. Shapiro from 1973 to 1975 how to "read & write" with plastic children's letters, following the training techniques of David Premack. The technique of conditional discrimination was used such that the orangutan could eventually distinguish plastic letter (symbols) as representations of referents (e.g., object, actions) and "read" an increasingly longer series of symbols to obtain a referent (e.g., fruit) or "write" an increasingly longer series of symbols to request or describe a referent. While no claim of linguistic competence was made, Aazk's performance demonstrated design features of language, many similar to those demonstrated by Premack's chimpanzee, Sarah.

Kanzi

Kanzi, a Bonobo, is believed to understand more human language than any other nonhuman animal in the world. Kanzi apparently learned by eavesdropping on the keyboard lessons researcher Sue Savage-Rumbaugh was giving to his adoptive mother. Kanzi learned to communicate with a Lexigram board, pushing symbols that stand for words. The board is wired to a computer, so the word is then vocalized out loud by the computer. This helps Kanzi develop his vocabulary and enables him to communicate with researchers.

One day, Rumbaugh used the computer to say to Kanzi, "Can you make the dog bite the snake?" It is believed Kanzi had never heard this sentence before. In answering the question, Kanzi searched among the objects present until he found a toy dog and a toy snake, put the snake in the dog's mouth, and used his thumb and finger to close the dog's mouth over the snake. In 2001, Alexander Fiske-Harrison, writing in the *Financial Times*, observed that "asked by an invisible interrogator through head-phones (to avoid cueing) to identify 35 different items in 180 trials. His success rate was 93 per cent." In further testing beginning when he was 7 ½ years old, Kanzi was asked 416 complex questions, responding correctly over 74% of the time. Kanzi has been observed verbalizing a meaningful noun to his sister.

Criticisms of primate language research

Some scientists, including MIT linguist Noam Chomsky and cognitive scientist Steven Pinker, are skeptical about claims made for great ape language research. Among the reasons for skepticism are the differences in ease with which human beings and apes can learn language, questions as to the whether there is a clear beginning and end to the signed gestures, and whether the apes actually understand language or are simply doing a clever trick for a reward.

While vocabulary words from American Sign Language are used to train the apes, native users of ASL note that mere knowledge of ASL's vocabulary does not equate to ASL, but more closely reflects Pidgin Signed English which is not a full-fledged language. In the research involving Washoe, all researchers returned lists of signs Washoe used, with the exception of the one deaf native ASL user who reported no signs but many gestures. Native users of ASL make clear distinctions about what handshapes, palm orientations and places of articulation signs must have to constitute linguistic activity. Signs must also be used combinatorially and in the correct grammatical sequence. Thus apes are seen as attempting to approximate these complex rules but are considered to be failing because of such malformations in the production of ASL signs. (However, proponents argue that such limitations might indicate instead that great ape ASL use more closely approximates a rudimentary stage of a young child's language development, or an early stage of an adult second language learner.)

Chapter 11

Animal Communication

Metacommunications: signals that modify the meaning of subsequent signals. The best known example is the *play face* and tail signals in dogs, which indicate that a subsequent aggressive signal is part of a play fight rather than a serious aggressive episode.

Animal communication is any behavior on the part of one animal that has an effect on the current or future behaviour of another animal. The study of animal communication, sometimes called **Zoosemiotics** (defined as the study of sign communication or semiosis in animals; distinguishable from anthroposemiotics, the study of human communication) has played an important part in the methodology of ethology, sociobiology, and the study of animal cognition.

Animal communication, and indeed the understanding of the animal world in general, is a rapidly growing field, and even in the 21st century so far, many prior understandings related to diverse fields such as personal symbolic name use, animal emotions, animal culture and learning, and even sexual conduct, long thought to be well understood, have been revolutionized.

Validation

A lamb investigates a rabbit, an example of interspecific communication through body language and scent.

Forms of communication

- Gestures: The best known form of communication involves the display of distinctive body parts, or distinctive bodily movements; often these occur in combination, so a distinctive movement acts to reveal or emphasize a distinctive body part. For example, the presentation of a parent Herring Gull's bill to its chick signals feeding time. Like many gulls, the Herring Gull has a brightly coloured bill, yellow with a red spot on the lower mandible near the tip. When it returns to the nest with food, the parent stands over its chick and taps the bill on the ground in front of it; this elicits a begging response from a hungry chick (pecking at the red spot), which stimulates the parent to regurgitate food in front of it. The complete signal therefore involves a distinctive morphological feature (body part), the red-spotted bill, and a distinctive movement (tapping towards the ground) which makes the red spot highly visible to the chick. Congruently, some cephalopods, such as the octopus, have specialized skin cells that can change the apparent colour, opacity, and reflectiveness of their skin. In addition to being used for camouflage, rapid changes in skin colour are used while hunting and in courtship rituals. While all primates use some form of gesture, Frans de Waal came to the conclusion that apes and humans are unique in that only they are able use intentional gestures to communicate. He tested the hypothesis of gesture evolving into language by studying the gestures of bonobos and chimps.

- Facial Expression: Facial gestures play an important role in animal communication. Dogs for example express anger through a snarling and showing their teeth. In alarm their ears will perk up. When fearful a dog will pull back their ears, expose teeth slightly and squint eyes. Jeffery Mogil studied the facial expressions of mice during increments of increasing pain. What they found were five recognizable facial expressions; orbital tightening, nose and check bulge, and changes in ear and whisker carriage.

- Gaze Following: Coordination among social animals is facilitated by monitoring of each others' head and eye orientation. Long recognized in human developmental studies as an important component of communication, there has recently begun to be much more attention on the abilities of animals to follow the gaze of those they interact with, whether members of their own species or humans. Studies have been conducted on apes, monkeys, dogs, birds, and tortoises, and have focused on two different tasks: "follow[ing] another's gaze into distant space" and "follow[ing] another's gaze geometrically around a visual barrier e.g. by repositioning themselves to follow a gaze cue when faced with a barrier blocking their view". The first ability has been found among a broad range of animals, while the second has been demonstrated only for apes, dogs (and wolves), and corvids (ravens), and attempts to demonstrate this "geometric gaze following" in marmosets and ibis gave negative results. Researchers do not yet have a clear picture of the cognitive basis of gaze following abilities, but developmental evidence indicates that "simple" gaze following and "geometric" gaze following are likely to rely on distinct cognitive foundations.

- Vocalization: Many animals communicate through vocalizations. Communication through vocalization is essential for many tasks including mating rituals, warning calls, conveying location of food sources, and social learning. Male mating calls are used to signal the female and to beat competitors in species such as hammer-headed bats, red deers, humpback whales and elephant seals . In whale species Whale song has been found to have different dialects based on location. Other instances of communication include the warning cries of the Campbell monkey, the territorial calls of gibbons, the use of frequency in Greater Spear-nosed bats to to distinguish between groups.

- Olafactory communication: Less obvious (except in a few cases) is olfactory communication. Many mammals, in particular, have glands that generate distinctive and long-lasting smells, and have corresponding behaviours that leave these smells in places where they have been. Often the scented substance is introduced into urine or feces. Sometimes it is distributed through sweat, though this does not leave a semi-permanent mark as scents deposited on the ground do. Some animals have glands on their bodies whose sole function appears to be to deposit scent marks: for example Mongolian gerbils have a scent gland on their stomachs, and a characteristic ventral rubbing action that deposits scent from it. Golden hamsters and cats have scent glands on their flanks, and deposit scent by rubbing their sides against objects; cats also have scent glands on their foreheads. Bees carry with them a pouch of material from the hive which they release as they reenter, the smell of which indicates that they are a part of the hive and grants their safe entry. Ants use pheromones to create scent trails to food as well as for alarm calls, mate attraction and to distinguish between colonies. Additionally, they have pheromones that are used to confuse an enemy and manipulate them into fighting with themselves.

- Electro Communication: A rarer form of animal communication is electrocommunication. It is seen primarily in aquatic life, though some mammals, notably the platypus and echidnas are capable of electroreception and thus theoretically of electrocommunication.

Functions of communication

While there are as many kinds of communication as there are kinds of social behaviour, a number of functions have been studied in particular detail. They include:

- agonistic interaction: everything to do with contests and aggression between individuals. Many species have distinctive threat displays that are made during competition over food, mates or territory; much bird song functions in this way. Often there is a matched submission display, which the threatened individual will make if it is acknowledging the social dominance of the threatener; this has the effect of terminating the aggressive episode and allowing the dominant animal unrestricted access to the resource in dispute. Some species also have *affiliative* displays which are made to indicate that a dominant animal accepts the presence of another.
- Courtship rituals: signals made by members of one sex to attract or maintain the attention of potential mate, or to cement a pair bond. These frequently involve the display of body parts, body postures (gazelles assume characteristic poses as a signal to initiate mating), or the emission of scents or calls, that are unique to the species, thus allowing the individuals to avoid mating with members of another species which would be infertile. Animals that form lasting pair bonds often have

symmetrical displays that they make to each other: famous examples are the mutual presentation of reeds by Great Crested Grebes, studied by Julian Huxley, the *triumph displays* shown by many species of geese and penguins on their nest sites and the spectacular courtship displays by birds of paradise and manakins.

- ownership/territorial: signals used to claim or defend a territory, food, or a mate.
- Food-related signals: many animals make "food calls" that attract a mate, or offspring, or members of a social group generally to a food source. When parents are feeding offspring, the offspring often have begging responses (particularly when there are many offspring in a clutch or litter - this is well known in altricial songbirds, for example). Perhaps the most elaborate food-related signal is the dance language of honeybees studied by Karl von Frisch. Young ravens signal to older, more experienced ravens when they come across new or untested food.
- Alarm calls: signals made in the presence of a threat from a predator, allowing all members of a social group (and often members of other species) to run for cover, become immobile, or gather into a group to reduce the risk of attack.
- Metacommunications: signals that modify the meaning of subsequent signals. The best known example is the *play face* in dogs, which signals that a subsequent aggressive signal is part of a play fight rather than a serious aggressive episode.

Interpretation of animal communication

It is important to note that whilst many gestures and actions have common, stereotypical meanings, researchers regularly seem to find that animal communication is often more complex and subtle than previously believed, and that the same gesture may have multiple distinct meanings depending on context and other behaviors. So generalizations such as "X means Y" are *often*, but not *always* accurate. For example, even a simple domestic dog's tail wag may be used in subtly different ways to convey many meanings including:

- Excitement
- Anticipation
- Playfulness
- Contentment/enjoyment
- Relaxation or anxiety
- Questioning another animal or a human as to intentions
- Tentative role assessment on meeting another animal
- Reassurance ("I'm hoping to be friendly, are you?")
- Brief acknowledgement ("I hear you", or "I'm aware and responsive if you want my attention")
- Statement of interest ("I want that (food/toy/activity), if you're willing")
- Uncertainty/apprehension
- Submissive placation (if worried by a more dominant animal)

Combined with other body language, in a specific context, many gestures such as yawns, direction of vision, and so on all convey meaning. Thus statements that a particular action "means" something should always be interpreted to mean "often means" something. As with human beings, who may smile or hug or stand a particular way for multiple reasons, many animals reuse gestures too.

Intraspecies vs. interspecies communication

The sender and receiver of a communication may be of the same species or of different species. The majority of animal communication is intraspecific (between two or more individuals of the same species). However, there are some important instances of interspecific communication. Also, the possibility of interspecific communication, and the form it takes, is an important test of some theoretical models of animal communication.

A European starling (*Sturnus vulgaris*) singing

Intraspecies communication

The majority of animal communication occurs within a single species, and this is the context in which it has been most intensively studied.

Most of the forms and functions of communication described above are relevant to intra-species communication.

Interspecies communication

Many examples of communication take place between members of different species. Animals communicate to other animals with various signs: visual, sound, echolocation, body language, and smell.

Prey to predator

If a prey animal moves or makes a noise in such a way that a predator can detect and capture it, that fits the definition of "communication" given above. This type of communication is known as interceptive eavesdropping, where a predator intercepts the message being conveyed to conspecifics.

This Chihuahua is baring his teeth to signify an attack is imminent if the photographer comes closer to take his bone.

There are however some actions of prey species that are clearly communications to actual or potential predators. A good example is warning colouration: species such as wasps that are capable of harming potential predators are often brightly coloured, and this modifies the behaviour of the predator, who either instinctively or as the result of experience will avoid attacking such an animal. Some forms of mimicry fall in the same category: for example hoverflies are coloured in the same way as wasps, and although they are unable to sting, the strong avoidance of wasps by predators gives the hoverfly some protection. There are also behavioral changes that act in a similar way to warning colouration. For example, canines such as wolves and coyotes may adopt an aggressive posture, such as growling with their teeth bared, to indicate they will fight if necessary, and rattlesnakes use their well-known rattle to warn potential predators of their poisonous bite. Sometimes, a behavioral change and warning colouration will be combined, as in certain species of amphibians which have a brightly coloured belly, but on which the rest of their body is coloured to blend in with their surroundings. When confronted with a potential threat, they show their belly, indicating that they are poisonous in some way.

Another example of prey to predator communication, is referred to as a pursuit-deterrent signal. Pursuit-deterrent signals occur when prey indicates to a predator that pursuit would be unprofitable because the signaler is prepared to escape. Pursuit-deterrent signals provide a benefit to both the signaler and receiver; they prevent the sender from wasting time and energy fleeing, and they prevent the receiver from investing in a costly pursuit that is unlikely to result in capture. Such signals can advertise prey's ability to escape, and reflect phenotypic condition (quality advertisement), or can advertise that the prey has detected the predator (perception advertisement). Pursuit-deterrent signals have been reported for a wide variety of taxa, including fish (Godin and Davis 1995), lizards (Cooper et al. 2004), ungulates (Caro 1995), rabbits (Holley 1993), primates (Zuberbuhler et al. 1997), rodents (Shelley and Blumstein 2005, Clark 2005), and birds (Alvarez 1993, Murphy 2006, 2007). The most familiar example of quality advertisement pursuit-deterrent signal is *stotting*, a pronounced combination of running while simultaneously hopping shown by some antelopes such as Thomson's gazelle in the presence of a predator. At least 11 hypothesis for stotting have been proposed. A leading theory today is that it alerts predators that the element of surprise has been lost. Predators like cheetahs rely on surprise attacks, proven by the fact that chases are rarely successful when they stot. Predators know not to waste energy on a chase that will likely be unsuccessful (optimal foraging behavior).

Predator to prey

Some predators communicate to prey in ways that change their behaviour and make them easier to catch, in effect deceiving them. A well-known example is the angler fish, which has a fleshy growth protruding from its forehead and dangling in front of its jaws; smaller fish try to take the lure, and in so doing are perfectly placed for the angler fish to eat them.

Symbiotic species

Interspecies communication also occurs in various kinds of mutualism and symbiosis. For example, in the cleaner fish/grouper system, groupers signal their availability for cleaning by adopting a particular posture at a cleaning station.

Human/animal communication

Various ways in which humans interpret the behavior of domestic animals, or give commands to them, fit the definition of interspecies communication. Depending on the context, they might be considered to be predator to prey communication, or to reflect forms of commensalism. The recent experiments on animal language are perhaps the most sophisticated attempt yet to establish human/animal communication, though their relation to natural animal communication is uncertain.

Lacking in the study of human-animal communication is a focus on expressive communication from animal to human specifically. Other than a few natural expressions animals (especially dogs) use to communicate to humans, scientists in general do not pursue expanding the expressive/productive communication of domesticated animals. Horses are taught to not communicate (for safety). Dogs and horses are generally not encouraged to communicate expressively, but are encouraged to develop receptive language (understanding). One scientist, Sean Senechal has pursued (since the late 1990's) developing, studying, and using the learned visible, expressive language in dogs and horses. By teaching these animals a gestural (human made) ASL-like language animals have been found to learn and use the new signs on their own to get what they need. Senechal's book Dogs Can Sign, Too documents this process.

Other aspects of animal communication

Evolution of communication

The importance of communication is clear from the fact that animals have evolved elaborate body parts to facilitate it. They include some of the most striking structures in the animal kingdom, such as the peacock's tail. Birdsong appears to have brain structures entirely devoted to its production. But even the red spot on a herring gull's bill, and the modest but characteristic bowing behaviour that displays it, require evolutionary explanation.

There are two aspects to the required explanation:

- identifying a route by which an animal that lacked the relevant feature or behaviour could acquire it;
- identifying the selective pressure that makes it adaptive for animals to develop structures that facilitate communication, emit communications, and respond to them.

Significant contributions to the first of these problems were made by Konrad Lorenz and other early ethologists. By comparing related species within groups, they showed that movements and body parts that in the primitive forms had no communicative function could be "captured" in a context where communication would be functional for one or both partners, and could evolve into a more elaborate, specialised form. For example, Desmond Morris showed in a study of grass finches that a beak-wiping response occurred in a range of species, serving a preening function, but that in some species this had been elaborated into a courtship signal.

The second problem has been more controversial. The early ethologists assumed that communication occurred for the good of the species as a whole, but this would require a process of group selection which is believed to be mathematically impossible in the evolution of sexually reproducing animals. Altruism towards an unrelated group is not widely accepted in the scientific community, but rather can be seen as a sort of reciprocal altruism, expecting the same behavior from others, a benefit of living in a group. Sociobiologists argued that behaviours that benefited a whole group of animals might emerge as a result of selection pressures acting solely on the individual. A gene-centered view of evolution proposes that behaviors that enabled a gene to become wider established within a population would become positively selected for, even if their effect on individuals or the species as a whole was detrimental.

In the case of communication, an important discussion by John Krebs and Richard Dawkins established hypotheses for the evolution of such apparently altruistic or mutualistic communications as alarm calls and courtship signals to emerge under individual selection. This led to the realisation that communication might not always be "honest" (indeed, there are some obvious examples where it is not, as in mimicry). The possibility of evolutionarily stable dishonest communication has been the subject of much controversy, with Amotz Zahavi in particular arguing that it cannot exist in the long term. Sociobiologists have also been concerned with the evolution of apparently excessive signalling structures such as the peacock's tail; it is widely thought that these can only emerge as a result of sexual selection, which can create a positive feedback process that leads to the rapid exaggeration of a characteristic that confers an advantage in a competitive mate-selection situation.

One theory to explain the evolution of traits like a peacock's tail is 'runaway selection'. This requires two traits-a trait that exists, like the bright tail, and a prexisting bias in the female to select for that trait. Females prefer the more elaborate tails, and thus those males are able to mate successfully. Exploiting the psychology of the female, a positive feedback loop is enacted and the tail becomes bigger and brighter. Eventually, the evolution will level off because the survival costs to the male do not allow for the trait to be elaborated any further. Two theories exist to explain runaway selection. The first is the good genes hypothesis. This theory states that an elaborate display is an honest signal of fitness and truly is a better mate. The second is the handicap hypothesis. This explains that the peacock's tail is a handicap, requiring energy to keep and makes it more visible to predators. Regardless, the individual is able to survive, even though its genes are not as good per se.

Cognitive aspects

Ethologists and sociobiologists have characteristically analysed animal communication in terms of more or less automatic responses to stimuli, without raising the question of whether the animals concerned understand the meaning of the signals they emit and receive. That is a key question in animal cognition. There are some signalling systems that seem to demand a more advanced understanding. A much discussed example is the use of alarm calls by vervet monkeys. Robert Seyfarth and Dorothy Cheney showed that these animals emit different alarm calls in the presence of different predators (leopards, eagles, and snakes), and the monkeys that hear the calls respond appropriately - but that this ability develops over time, and also takes into account the experience of the individual emitting the call. Metacommunication, discussed above, also seems to require a more sophisticated cognitive process.

A recently published paper demonstrated that bottlenose dolphins can recognize identity information from whistles even when otherwise stripped of the characteristics of the whistle; making dolphins the only animals other than humans that have been shown to transmit identity information independent of the caller's voice or location. The paper concludes that:

The fact that signature whistle shape carries identity information independent from voice features presents the possibility to use these whistles as referential signals, either addressing individuals or referring to them, similar to the use of names in humans. Given the cognitive abilities of bottlenose dolphins, their vocal learning and copying skills, and their fission–fusion social structure, this possibility is an intriguing one that demands further investigation.
—V. M. Janik, *et al.*

Animal communication and human behaviour

Another controversial issue is the extent to which humans have behaviours that resemble animal communication, or whether all such communication has disappeared as a result of our linguistic capacity. Some of our bodily features - eyebrows, beards and moustaches, deep adult male voices, perhaps female breasts - strongly resemble adaptations to producing signals. Ethologists such as Irenäus Eibl-Eibesfeldt have argued that facial gestures such as smiling, grimacing, and the *eyebrow flash* on greeting are universal human communicative signals that can be related to corresponding signals in other primates. Given the recency with which spoken language has emerged, it is very likely that human body language does include some more or less involuntary responses that have a similar origin to the communication we see in other animals.

Humans also often seek to mimic animals' communicative signals in order to interact with the animals. For example, cats have a mild affiliative response involving closing their eyes; humans often close their eyes towards a pet cat to establish a tolerant relationship. Stroking, petting and rubbing pet animals are all actions that probably work through their natural patterns of interspecific communication.

Dogs have shown an ability to understand communication from a species other than their own. They were able to use human communicative gestures such as pointing and looking to find hidden food and toys.

A new approach in the 21 century of studying animal communication uses applied behavioral analysis (ABA), specifically Functional Communication Training (FCT). This FCT previously has been used in schools and clinics with humans with special needs, such as children with autism, to help them develop language. Sean Senechal, at the AnimalSign Center has been using an approach similar to this FCT with domesticated animals, such as dogs (since 2004) and horses (since 2000) with encouraging results and benefits to the animals and people. Functional communication training for animals, Senechal calls AnimalSign Language. This includes teaching communication through gestures (like simplified ASL), pictures (PECS), tapping, and vocalization. The process for animals includes simplified and modified techniques.

Animal communication and linguistics

For linguistics, the interest of animal communication systems lies in their similarities to and differences from human language:

1. Human languages are characterized for having a **double articulation** (in the characterization of French linguist André Martinet). It means that complex linguistic expressions can be broken down in meaningful elements (such as morphemes and words), which in turn are composed of smallest phonetic elements that affect meaning, called phonemes. Animal signals, however, do not exhibit this dual structure.
2. In general, animal utterances are responses to external stimuli, and do not refer to matters removed in time and space. Matters of relevance at a distance, such as distant food sources, tend to be indicated to other individuals by body language instead, for example wolf activity before a hunt, or the information conveyed in honeybee dance language. It is therefore unclear to what extent utterances are automatic responses and to what extent deliberate intent plays a part.
3. Human language is largely learned culturally, while animal communication systems are known largely by instinct.
4. In contrast to human language, animal communication systems are usually not able to express conceptual generalizations. (Cetaceans and some primates may be notable exceptions).
5. Human languages combine elements to produce new messages (a property known as **creativity**). One factor in this is that much human language growth is based upon conceptual ideas and hypothetical structures, both being far greater capabilities in humans than animals. This appears far less common in animal communication systems, although current research into animal culture is still an ongoing process with many new discoveries.

A recent and interesting area of development is the discovery that the use of syntax in language, and the ability to produce "sentences", is not limited to humans either. The first good evidence of syntax in non-humans, reported in 2006, is from the greater spot-nosed monkey (*Cercopithecus Nictitans*) of Nigeria. This is the first evidence that some animals can take discrete units of communication, and build them up into a sequence which then carries a different meaning from the individual "words":

The putty-nosed monkeys have two main alarm sounds. A sound known onomatopoeiacally as the 'pyow' warns against a lurking leopard, and a coughing sound that scientists call a 'hack' is used when an eagle is hovering nearby.
"Observationally and experimentally we have demonstrated that this sequence [of up to three 'pyows' followed by up to four 'hacks'] serves to elicit group movement... the 'pyow-

hack' sequence means something like "let's go!" [a command telling others to move]... The implications are that primates at least may be able to ignore the usual relationship between an individual alarm call, and the meaning it might convey under certain circumstances... To our knowledge this is the first good evidence of a syntax-like natural communication system in a non-human species."

Chapter 12

Animal Training

Animal trainer

Early 20th Century animal trainer and a leopard.

Occupation	
Names	animal trainer
Type	performing arts
Activity sectors	social science, busking, circus, show business
Description	
Competencies	skills, manual dexterity
Education required	
Fields of employment	police, education, entertainment

Animal training refers to teaching animals specific responses to specific conditions or stimuli. Training may be for the purpose of companionship, detection, protection, entertainment or all of the above.

An **animal trainer** may use reinforcement or punishment to condition an animal's responses. Some animal trainers may have a knowledge of the principles of behavior analysis and operant conditioning, but there are many ways to train animals and no legal requirements or certifications are required.

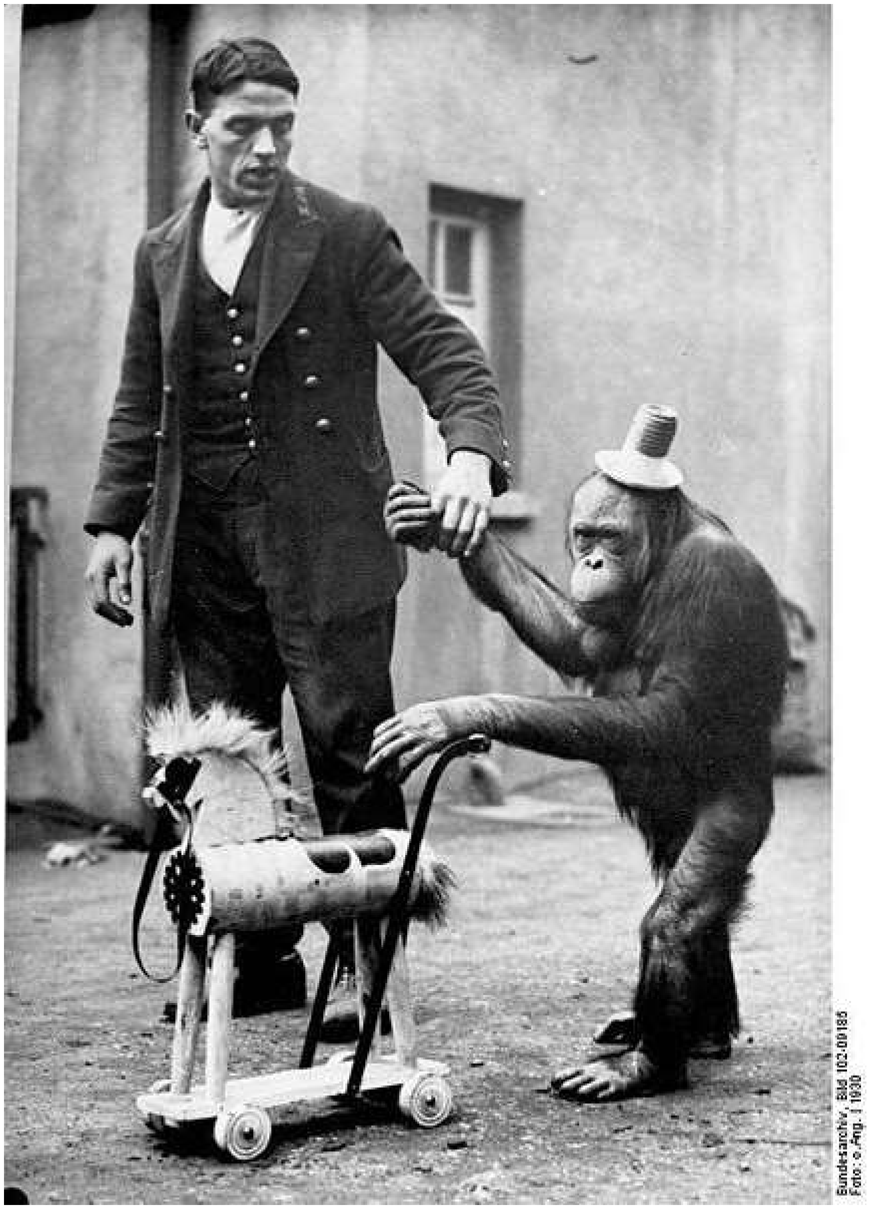
Formation

The certification bodies that do exist (in some, not all, countries) do not share consistent goals or requirements so it can be difficult to tell what kind of training a trainer has had to do his or her job. The United States does not require animal trainers to have any kind of certification or psychological screening.

The type of training is often determined by the trainer's motivation, background, and psychological make-up. An individual training a seeing eye dog, for example, will have a different approach and end-goal than an individual training a wild animal to do tricks in a circus.

Ideally, animal trainers will try to use positive reinforcement (follow a desired behavior with something worthwhile to the animal and the behavior will increase) and negative punishment (withdraw something the animal wants when he performs undesirable behaviors). Traditional trainers often rely on positive punishment (follow an undesirable behavior with a punishment to reduce the rate of the behavior) and negative reinforcement (withdraw an undesirable stimulus when the animal performs the desirable behavior).

Service animals



Morphy, an Orangutan with his toy, a horse, on a walk with his keeper in a traveling circus.

Service animals, such as assistance dogs, capuchin monkeys and horses, are trained to utilize their sensory and social skills to bond with a human and help that person to offset a disability in daily life. The use of service animals, especially dogs, is an ever-growing field, with a wide range of special adaptations.

In the United States, selected inmates in prisons are used to train service dogs. In addition to adding to the short-supply of service animals, such programs have produced benefits in improved socialization skills and behavior of inmates.

Film and television

Organizations such as the American Humane Association monitor the use of animals such as those used in the entertainment industry, but they do not monitor their training. The Patsy Award (Picture Animal Top Star of the Year) was originated by the Hollywood office in 1939. They decided to honor animal performers after a horse was killed in an on-set accident during the filming of the Tyrone Power film *Jesse James*.

The award now covers both film and television and is separated into four categories: canine, equine, wild and special. The special category encompasses everything from goats to cats to pigs. One famous animal trainer, Frank Inn, received over 40 Patsy awards.

Patience and repetition are critical components of successful animal training. Inn's most famous animal was Higgins, who came from the Burbank, California Animal Shelter. Inn began training animals while incapacitated due to an automobile accident. Higgins starred in the *Petticoat Junction* sitcom in the 1960s and the first two *Benji* films in 1974 and 1977.

Lifetime bonds are often made between trainers and animals. The ashes of Higgins were buried with trainer Inn when he died in 2002.

Companion animals

Dogs

A trained dog competing in dog agility.

Basic obedience training tasks for dogs include walking on a leash, attention, housebreaking, nonaggression, and socialization with humans or other pets. Dogs are also trained for many other activities, such as dog sports, service dogs, and other working dog tasks.

Positive reinforcement for dogs can include primary reinforcers such as food, or social reinforcers such as vocal ("good boy") or tactile (stroking) ones. Positive punishment, if used at all, can be physical, such as pulling on a leash or spanking, or may be vocal ("bad dog"). Bridges to positive reinforcement include vocal cues, whistling, and dog whistles, as well as clickers used in clicker training, a method popularized by Karen Pryor. Negative reinforcement may also be used. Punishment is also a tool, including withholding of food or physical discipline.

Horses

The primary purpose of training horses is to socialize them to be around humans, teach them to behave in a manner that makes them safe for humans to handle, and, as adults to carry a rider under saddle or to be driven in order to pull a vehicle. As prey animals, much effort must be put into training horses to overcome its natural flight or fight instinct and accept handling that would not be natural for a wild animal, such as willingly going into a confined space, or having a predator (a human being) sit on its back. As training advances, some horses are prepared for competitive sports, up to the Olympic games, where horses are the only animal athlete that is used at the Olympics. All equestrian disciplines from horse racing to draft horse showing require the horse to have specialized training.

A human with a trained horse and a trained Peregrine Falcon

Unlike dogs, horses are not motivated as strongly by positive reinforcement rewards as they are motivated by other operant conditioning methods such as the release of pressure as a reward for the correct behavior, called negative reinforcement. Positive reinforcement techniques such as petting, kind words, rewarding of treats, and clicker training have some benefit, but not to the degree seen in dogs and other predator species. Punishment of horses is effective only to a very limited degree, usually a sharp command or brief physical punishment given within a few seconds of a disobedient act. Horses do not correlate punishment to a specific behavior unless it occurs immediately. They do, however, have a remarkably long memory, and once a task is learned, it will be retained for a very long time. For this reason, poor training or allowing bad habits to be learned can be very difficult to remedy at a later date.

Birds

Typical training tasks for companion birds include perching, non-aggression, halting feather-picking, controlling excessive vocalizations, socialization with household members and other pets, and socialization with strangers. The large parrot species frequently have lifespans that exceed that of their human owners, and they are closely bonded to their owners. In general, parrot companions usually have clipped wings, which facilitates socialization and controlling aggression and vocalizations. Some birds of prey are trained to hunt, an ancient art known as falconry or hawking. In China the practice of training Cormorants to catch fish has gone on for over 1,200 years.

Chickens

Chicken on a skateboard

Training chickens has become a way for trainers of other animals (primarily dogs) to perfect their training technique. Bob Bailey, formerly of Animal Behavior Enterprises and the IQ Zoo, teaches chicken training seminars where trainers teach poultry to discriminate between shapes, to navigate an obstacle course and to chain behaviors together. Chicken training is done using operant conditioning, using a clicker and chicken feed for reinforcement. The training of chickens has become a popular event for dog trainers. Trained chickens may be confined to a fiberglas box where they play Tic-Tac-Toe against humans for a fee.

Fish

Fish can also be trained. For example, a goldfish may swim toward its owner and follow him as he walks through the room, but will not follow anyone else. The fish may swim up and down, signaling the owner to turn on its aquarium light when it is off, and it will skim the surface until its owner feeds it. Pet goldfish have also been taught to perform more complicated tasks, such as doing the limbo and pushing a miniature soccer ball into a net.

Wild animals

Wild animal training

Wild animals may also be trained, such as bears, lions, tigers, leopards, or other big cats. The Ursari Romani people were specialized in bear training, although they sometimes also used Old World monkeys. Later on, the German animal merchant Carl Hagenbeck, used brown bears and lions in his shows.

Zoological parks

Animals in public display are sometimes trained for educational, entertainment, management, and husbandry behaviors. Educational behaviors may include species-typical behaviors under stimulus control such as vocalizations. Entertainment may include display behaviors to show the animal, or simply arbitrary behaviors. Management includes movement, such as following the trainer, entering crates, or moving from pen to pen, or tank-to-tank through gates. Husbandry behaviors facilitate veterinary care, and can include desensitization to various physical examinations or procedures (such as cleaning, nail clipping, or simply stepping onto a scale voluntarily), or the collection of samples (e.g. biopsy, urine). Such voluntary training is important for minimizing the frequency with which zoo collection animals must be anesthetized or physically restrained.

Marine mammal parks

Many marine mammals are trained for entertainment such as bottlenose dolphins, killer whales, belugas, sea lions, and others. In a public display situation, the audience's attention is focused on the animal, rather than the trainer; therefore the discriminative stimulus is generally gestural (a hand sign) and sparse in nature. Unobtrusive dog whistles are used as bridges, and positive reinforcers are either primary (food) or tactile (rub downs), and not vocal. However, pinnipeds and mustelids (sea lions, seals, walruses, and otters) can hear in our frequency, so most of the time they will receive vocal reinforcers during shows and performances. The shows are turned into more of a play production because of this, instead of just a run through of behaviors like cetaceans generally do in their shows. Guests can often hear these vocal reinforcers when attending a Sea World show. During the Clyde and Seamore show, the trainers may say something like: "Good grief, Clyde!" or "Good job, Seamore". The trainers substitute the word "good" in the place of food or rubdowns when teaching a specific behavior to the animals so that the animals no longer need constant feeding as praise for achieving the appropriate behavior.

Methods

The Ursar, drawing by Theodor Aman

Animal training is generally performed in adherence to the theory of operant conditioning, although modern training methods frequently utilize tools not included in the original Skinnerian conception.

Two primary types of training philosophies are those that emphasize *positive reinforcement*, and those that use *negative reinforcement*, which is not to be confused with punishment. Certain subfields of animal training tend to also have certain philosophies and styles, for example fields such as companion bird training, hunting bird training, companion dog training, show dog training, dressage horse training, mahout elephant training, circus elephant training, zoo elephant training, zoo exotic animal training, marine mammal training. The degree of trainer protection from the animal may also vary. The variety of tasks trained may also vary, and can range from entertainment, husbandry (veterinary) behaviors, physical labor or athleticism, habituation to averse stimuli, interaction (or non-interaction) with other humans, or even research (sensory, physiological, cognitive).

Training also may take into consideration the natural social tendencies of the animal species (or even breed), such as predilections for attention span, food-motivation, dominance hierarchies, aggression, or bonding to individuals (conspecifics as well as humans). Consideration must also be given to practical aspects on the human side such as the ratio of the number of trainers to each animal. In some circumstances one animal may have multiple trainers, in others, a trainer might attend simultaneously to many animals in a training session. Sometimes training is accomplished with a single trainer working individually with a single animal.

Other important issues related to the methods of animal training are: operant conditioning, stimulus control, SD (discriminative stimulus), desensitization, chaining, bridge, and the s-delta.

List of notable animal trainers

Known for their influence on the circus:

- Nadezhda Durova (1783–1866) founded the Durov family of performers in the Russian circus.
- Anatoly Durov (1887–1928) Russian circus animal trainer and founder of the Durov Animal Theater in Moscow.
- Carl Hagenbeck (1844–1913) a merchant of wild animals who introduced "natural" animal enclosures.
- Gunther Gebel-Williams (1934–2001) trained animals for the Ringling Bros. and Barnum & Bailey Circus.
- Mike Baray, (born 1938) animal trainer, performed with Sarrasani, Jean Richard, Bouglione, occasional performer with E. Raluy's Circus Williams.
- Martin Lacey, (born 1947), animal trainer, owner of the Great British Circus, trained most of the tigers used in the ESSO TV advertisements in the 1970s.
- Martin Lacey, Jr., (born 1977), son of Martin, an animal trainer and performer with Circus Krone in Munich.
- Alex Lacey, also son of Martin, animal trainer and performer.

Known for scientific research:

- Ivan Pavlov (1849–1946) studied the psychology of animal training and described the phenomenon of classical conditioning.
- Karen Pryor (1932–), used applied operant conditioning with marine mammals and dog clicker training

Known for work in television and film:

- Nell Shipman (1892–1970) a Canadian film maker in early Hollywood.
- Frank Inn (1916–2002) trained dogs used in the Benji series.
- Brothers Frank Weatherwax and Rudd Weatherwax trained the collie Pal who portrayed the first Lassie.
- Ralph Helfer
- Dr. Bhagavan Antle, trained exotic animals for movies including Jungle Book, Dr. Dolittle and Mighty Joe Young
- Mathilde DeCagny trained Moose, best known as Eddie Crane on the television sitcom Frasier.

Other:

- Felix Ho, professional dog behaviorist, international dog sport championship competitor and judge
- Warren Eckstein, animal trainer, author and radio personality.
- Victoria Stilwell, dog trainer, author and television presenter.
- Dave Salmoni, animal trainer, entertainer, and producer.

Chapter 13

Animal Language

Animal language is the modeling of human language in non human animal systems. While the term is widely used, researchers agree that animal languages are not as complex or expressive as human language.

Some researchers including the linguist Charles Hockett, who proposed a list of design features of Human Language, argue that there are significant differences separating human language from animal communication even at its most complex, and that the underlying principles are not related. Accordingly, Thomas A. Sebeok has proposed not to use the term 'language' in case of animal sign systems.

Others argue that an evolutionary continuum exists between the communication methods these animals use and human language. Examining this continuum could help explain how humanity evolved its incredibly sophisticated proficiency for language.

Aspects of human language

Human and ape, in this case Claudine Andre with a bonobo.

The following properties of human language have been argued to separate it from animal communication:

- *Arbitrariness:* There is no rational relationship between a sound or sign and its meaning. (There is nothing intrinsically "housy" about the word "house". i.e. *symbolism*)
- *Cultural transmission:* Language is passed from one language user to the next, consciously or unconsciously.
- *Discreteness:* Language is composed of discrete units that are used in combination to create meaning.
- *Displacement:* Languages can be used to communicate ideas about things that are not in the immediate vicinity either spatially or temporally, or both.
- *Duality:* Language works on two levels at once, a surface level and a semantic (meaningful) level.
- *Metalinguistics:* Ability to discuss language itself.
- *Productivity:* A finite number of units can be used to create an indefinitely large number of utterances.

Research with apes, like that of Francine Patterson with Koko or Herbert Terrace with Nim Chimpsky, suggested that apes are capable of using language that meets some of these requirements. However, no experiment has shown a non-human being to be proficient in all of these areas.

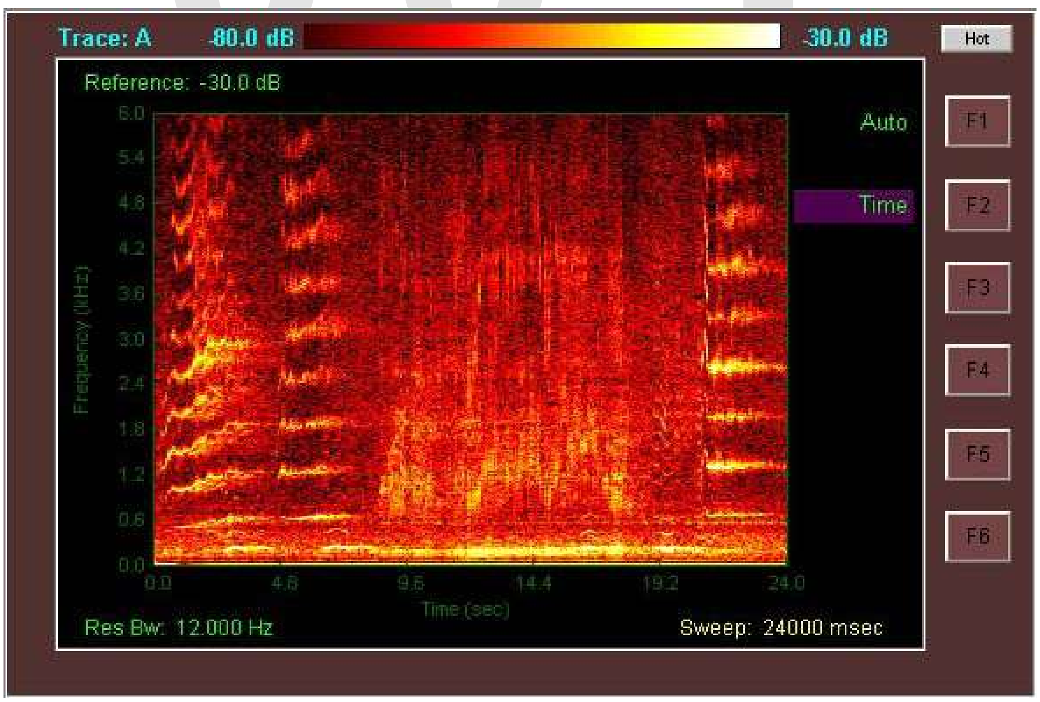
In the wild chimpanzees have been seen "talking" to each other, when warning about approaching danger. For example, if one chimpanzee sees a snake, he makes a low, rumbling noise, signalling for all the other chimps to climb into nearby trees. In this case, the chimpanzees' communication is entirely contained to an observable event, demonstrating a lack of displacement.

Arbitrariness has been noted in meerkat calls; bee dances show elements of spatial displacement; and cultural transmission has possibly occurred between the celebrated bonobos Kanzi and Panbanisha.

Human language may not be completely "arbitrary". Some research has shown that almost all humans naturally demonstrate limited crossmodal perception (e.g. synesthesia), as illustrated by the Kiki and Booba study.

Claims that animals have language skills akin to humans however, are extremely controversial. As Pinker illustrates in his book the "The Language Instinct", claims that chimpanzees can acquire language are exaggerated and rest on very limited or specious data.

Non-Primates: Studied examples



Spectrogram of Humpback Whale vocalizations. Detail is shown for the first 24 seconds of the 37 second recording Humpback Whale "Song".

The most studied examples of animal languages are:

- Bee dance - used to communicate direction and distance of food source in many species of bees.
- Bird songs - songbirds can be very articulate. African Grey Parrots are famous for their ability to mimic human language, and at least one specimen, Alex, appeared able to answer a number of simple questions about objects he is presented with. Parrots, hummingbirds and songbirds- display vocal learning patterns.
- Whale songs - Two groups of whales, the Humpback Whale and the subspecies of Blue Whale found in the Indian Ocean, are known to produce the repetitious sounds at varying frequencies known as whale song. Male Humpback Whales perform these vocalizations only during the mating season, and so it is surmised the purpose of songs is to aid sexual selection. Humpbacks also make a sound called the feeding call. This is a long sound (5 to 10 s duration) of near constant frequency. Humpbacks generally feed cooperatively by gathering in groups, swimming underneath shoals of fish and all lunging up vertically through the fish and out of the water together. Prior to these lunges, whales make their feeding call. The exact purpose of the call is not known, but research suggests that fish react to it. When the sound was played back to them, a group of herring responded to the sound by moving away from the call, even though no whale was present.
- Prairie dog language: Dr. Slobodchikoff studied prairie dog communication and made the following discoveries. His current findings are that prairie dogs have:
  - different alarm calls for different species of predators;
  - different escape behaviors for different species of predators;
  - transmission of semantic information, in that playbacks of alarm calls in the absence of predators lead to escape behaviors that are appropriate to the type of predator which elicited the alarm calls;
  - alarm calls containing descriptive information about the general size, color, and speed of travel of the predator.
- Caribbean Reef Squid have been shown to communicate using a variety of color, shape, and texture changes. Squid are capable of rapid changes in skin color and pattern through nervous control of chromatophores. In addition to camoflauge and appearing larger in the face of a threat, squids use color, patterns, and flashing to communicate with one another in various courtship rituals. Caribbean Reef Squid can send one message via color patterns to a squid on their right, while they send another message to a squid on their left.

Comparison of the term with "animal communication"

It is worth distinguishing "animal language" from "animal communication", no matter how complex the latter may be. In general the term "animal language" is reserved for the modeling of human language in animal systems; though there is some comparative interchange in certain cases (e.g. Cheney & Seyfarth's vervet monkey call studies). Thus "animal language" typically does not include bee dancing, bird song, whale song, dolphin signature whistles, prairie dogs, nor the communicative systems found in most social mammals. The features of language as listed above are a dated formulation by Hockett in 1960. Through this formulation Hockett made one of the earliest attempts to break down features of human language for the purpose of applying Darwinian gradualism. Although an influence on early animal language efforts (see below), is today not considered the key architecture at the core of "animal language" research.

"Clever Hans", an Orlov Trotter horse that was claimed to have been able to perform arithmetic and other intellectual tasks.

Animal Language results are controversial for several reasons. In the 1970s John Lilly was attempting to "break the code": to fully communicate ideas and concepts with wild populations of dolphins so that we could "speak" to them, and share our cultures, histories, and more. This effort failed. The very early [chimpanzee] work was with chimpanzee infants raised as if they were human; a test of the nature vs. nurture hypothesis. Chimpanzees have a laryngeal structure very different from that of humans, as well as no voluntary control of their breathing. This combination made it very difficult for the chimpanzees to reproduce the vocal intonations required for human language. Researchers eventually moved towards a gestural (sign language) modality, as well as "keyboard" devices laden with buttons adorned with symbols (known as "lexigrams") that the animals could press to produce artificial language. Other chimpanzees learned by observing human subjects performing the task. This latter group of researchers studying chimpanzee communication through symbol recognition (keyboard) as well as through the use of sign language (gestural), are on the forefront of communicative breakthroughs in the study of animal language, and they are familiar with their subjects on a first name basis: Sarah, Lana, Kanzi, Koko, Sherman, Austin and Chantek.

Perhaps the best known critic of "Animal Language" is Herbert Terrace. Terrace's 1979 criticism using his own research with the chimpanzee Nim Chimpsky was scathing and basically spelled the end of animal language research in that era, most of which emphasized the production of language by animals. In short, he accused researchers of over-interpreting their results, especially as it is rarely parsimonious to ascribe true intentional "language production" when other simpler explanations for the behaviors (gestural hand signs) could be put forth. Also, his animals failed to show generalization of the concept of reference between the modalities of comprehension and production; this generalization is one of many fundamental ones that are trivial for human language use. The simpler explanation according to Terrace was that the animals had learned a sophisticated series of context-based behavioral strategies to obtain either primary (food) or social reinforcement, behaviors that could be over-interpreted as language use.

In 1985 during this anti-Animal Language backlash, Louis Herman published an account of artificial language in the bottlenosed dolphin in the journal Cognition. A major difference between Herman's work and previous research was his emphasis on a method of studying language comprehension only (rather than language comprehension and production by the animal(s)), which enabled rigorous controls and statistical tests, largely because he was limiting his researchers to evaluating the animals' physical behaviors (in response to sentences) with blinded observers, rather than attempting to interpret possible language utterances or productions. The dolphins' names here were Akeakamai and Phoenix. Irene Pepperberg used the vocal modality for language production and comprehension in an African Grey Parrot named Alex in the verbal mode, and Sue Savage-Rumbaugh continues to study Bonobos such as Kanzi and Panbanisha. R. Schusterman duplicated many of the dolphin results in his California Sea Lions ("Rocky"), and came from a more behaviorist tradition than Herman's cognitive approach. Schusterman's emphasis is on the importance on a learning structure known as "equivalence classes."

However, overall, there has not been any meaningful dialog between the linguistics and animal language spheres, despite capturing the public's imagination in the popular press. Also, the growing field of language evolution is another source of future interchange between these disciplines. Most primate researchers tend to show a bias toward a shared pre-linguistic ability between humans and chimpanzees, dating back to a common ancestor, while dolphin and parrot researchers stress the general cognitive principles underlying these abilities. More recent related controversies regarding animal abilities include the closely linked areas of Theory of mind, Imitation (e.g. Nehaniv & Dautenhahn, 2002), Animal Culture (e.g. Rendell & Whitehead, 2001), and Language Evolution (e.g. Christiansen & Kirby, 2003).

Chapter 14

Human-Animal Communication

Human-animal communication is easily observed in everyday life. The interactions between pets and their owners, for example, reflect a form of spoken, while not necessarily verbal, dialogue. A dog being scolded does not need to understand every word of its admonishment, but is able to grasp the message by interpreting cues such as the owner's stance, tone of voice, and body language. This communication is two-way, as owners can learn to discern the subtle differences between barks and meows … one hardly has to be a professional animal trainer to tell the difference between the bark of an angry dog defending its home and the happy bark of the same animal while playing. Communication (often nonverbal) is also significant in equestrian activities such as dressage.

Word repetition in birds

Although the word repetition skills observed in some birds (most famously parrots) should not be mistaken for lingual communication, this tendency has nonetheless influenced fictional portrayals of animal communication, as sentient talking parrots and similar birds are common in children's fiction, such as the talking, loud-mouth parrot Iago of Disney's *Aladdin*. Bruce Thomas Boehner's book *Parrot Culture: Our 2,500-Year-Long Fascination with the World's Most Talkative Bird* explores this issue thoroughly.

The next level: language

Achieving a deeper level of communication between animals and humans has long been a goal of science. Perhaps the most famous example of recent decades has been Koko, a gorilla who is supposedly able to communicate with humans using a system based on American Sign Language with a "vocabulary" of over 1000 words.

John Lilly and Cetacean Communication

In the 1960s, John Lilly, M.D., prolific writer and explorer of consciousness via the isolation tank (his invention) and LSD, and contemporary and associate of Timothy

Leary, began experiments in the Virgin Islands aiming to establish meaningful communication between humans and the bottlenose dolphin (*Tursiops truncatus*). Lilly financed, mostly personally, a human-dolphin cohabitat, a house on the ocean's shore that contained an area that was partially flooded and allowed a human and dolphin to live together in the same space, sharing meals, play, language lessons, and even sleep.

Two experiments of this sort are explained in detail in Lilly's popular books. The first experiment was more of a test run to check psychological and other strains on the human and cetacean participants, determining the extent of the need for other human contact, dry clothing, time alone, and so on. Despite tensions after several weeks, the experimenter, Margaret C. Howe, agreed to a two-and-a-half month experiment, living isolated with 'Peter' dolphin.

A basic outline of Peter dolphin's linguistic progress is as follows: early lessons involved mostly noise and interruptions from Peter during English lessons, and a food reward of fish was necessary for him to 'attend class.' After several weeks, a concerted effort by Peter to imitate the instructor's speech was evident, and human-like sounds were apparent, and recorded. More interesting was the dolphin's immediate grasp of basic semantics, such as the different aural indicators for 'ball' and 'doll' and other toys present in the aquarium. Peter was able to perform tasks such as retrieval on the (aurally) indicated object without fail. Later in the project the dolphin's ability to process linguistic syntax was made apparent, in that Peter could distinguish between the commands (e.g., only) "Bring the ball to the doll," and "Bring the doll to the ball." This ability not only demonstrates the bottlenose dolphin's grasp of basic grammar, but also implies the dolphins' own language must include some such syntactical rules. The correlation between length and 'syllables' (bursts of the dolphin's sound) with the instructor's speech also went from essentially zero at the beginning of the session to almost a perfect correlation by its completion. I.e., a sentence spoken by the instructor involving 35 syllables and lasting 8 seconds would be met with an 8-second burst of sound from Peter dolphin involving 35 easily-discernible 'syllables' or bursts of sound.

Much later, experiments by Louis Herman, a former collaborator and student of Lilly's, demonstrated the crossmodal perceptual ability of dolphins. Dolphins typically perceive their environment through sound waves generated in the melon of their skulls, through a process known as echolocation (similar to that seen in bats, though the mechanism of production is different). The dolphin's eyesight however is also fairly good, even by human standards, and Herman's research found that any object, even of complex and arbitrary shape, identified either by sight or sound by the dolphin, could later be correctly identified by the dolphin with the alternate sense modality with almost 100 per cent accuracy, in what is classically known in psychology and behaviorism as a match-to-sample test. The only errors noted were presumed to have been a misunderstanding of the task during the first few trials, and not an inability of the dolphin's perceptual apparatus. This capacity is strong evidence for abstract and conceptual thought in the dolphin's brain, wherein an idea of the object is stored and understood not merely by its sensory properties; such abstraction may be argued to be of the same kind as complex language, mathematics, and art, and implies a potentially very great intelligence and conceptual understanding within the brains of tursiops and possibly many other cetaceans. Accordingly, Lilly's interest later shifted to whale song and the possibility of high intelligence in the brains of large whales, and Louis Herman's research at the now misnomered Dolphin Institute in Honolulu, Hawaii, focuses exclusively on the Humpback whale.

Animal communication as entertainment

Though animal communication has always been a topic of public comment and attention, for a period in history it surpassed this and became sensational popular entertainment. From the late 18th century through the mid 19th century, a succession of "learned pigs" and various other animals were displayed to the public in for-profit performances, boasting the ability to communicate with their owners (often in more than one language), write, solve math problems, and the like. One poster dated 1817 shows a group of "Java sparrows" who are advertised as knowing *seven languages*, including Chinese and Russian. One pig of the era was so famous that it performed for royalty, and an obituary upon its death claimed that it made more money than any actor or actress of the same time; a fact that, whether strictly true, was at least believable to contemporary readers. By the late 1840s the fad had died down considerably. While the occasional appearance by a "learned" animal continued into the radio and television eras, it was by then generally understood that feats such as using cards to spell words, barking or tapping a hoof to solve equations, and the like were the products of training rather than actual *communication*. Though the tradition continues to this day on the "Stupid Pet Tricks" segment of Late Night with David Letterman, it seems likely that the era of trained pigs entertaining the crowned heads of Europe are over.

BowLingual

One real-world example of a technological means of one-way human-animal communication is BowLingual, a Japanese device which claims to translate barks from dozens of different breeds of dogs, including mixed-breeds. Based largely on Dr. Matsumi Suzuki's Animal Emotion Analysis System developed at Japan Acoustic Laboratory, the device outputs one of 200 phrases (grouped into six different moods), supposedly reflecting "meaning" of the dog's bark. The device was apparently successful enough in Japan to be brought to the American market, and was even named one of 2002's best inventions by Time Magazine. However, reports of the BowLingual's accuracy have been mixed at best, with popular product-review website Epinions giving it a low 1.5 stars average.

Human-animal communication in culture

The concept of human-animal communication has existed in culture for longer than recorded history, being an element of many myths and folk tales of numerous cultures, and continues in modern popular entertainment. Here we, lists some examples of this, divided by the method of communication (magical/supernatural, innate natural ability, technological, and unspecified/misc).

Magic and supernatural

- In many fantasy role playing games, Druid characters are able to speak with animals through the use of a spell. The Dungeons & Dragons version of this spell is called "Speak with Animals".
- Eliza Thornberry of Nickelodeon's animated TV series The Wild Thornberrys can speak with animals after a spell is placed on her by an African tribal shaman.
- In the Harry Potter series of books, Harry is a parselmouth (able to speak with snakes in their own language, parseltongue, which sounds like hissing and spitting to the ears of those without this (apparently hereditary) skill).
- In The Immortals series of books, Veralidaine Sarrasri (Daine) has "wild magic" which enables her to communicate with animals. After being trained in the use of her wild magic, she learns to enter the minds of animals and shapeshift.

Innate ability

- Cypher, real name Douglas Ramsey, of Marvel Comics' The New Mutants, has a "mutant" ability to instantly translate any language he hears or sees, including animal languages.
- Doctor Dolittle, subject of a series of children's books by Hugh Lofting as well as various film and stage adaptions, is a doctor whose ability to speak with animals makes him successful in dealing with animals but closes him off from most humans.

Technological

- In Star Trek, the communicator badges worn by Starfleet crew members allow direct translation between humans and various sentient and semi-sentient aliens and creatures, though it is undetermined whether they work with "dumb" animals. It is presumed that this is not possible, as the relatively few domesticated animals seen on the show do not appear to converse with their owners (Data's cat, and Archer's beagle, for example). The council-chamber of the Xindi accommodates her Aquatic members in a water-tank.
- In issue 285 of DC's Detective Comics, Martian Manhunter fights a brigade of "Martian mandrills" which were being manipulated by villains through the use of a communicator device stolen from the mandrills' rocket.
- On the television cartoon Krypto the Superdog, Krypto has an "intergalactic communicator" device in his dog tag, which allows Kevin Whitney to communicate with him. The device is technology from Krypton, Superman's homeworld.

Unspecified and miscellaneous

- In Hergé's *Tintin* comics, Tintin's dog Snowy is sentient and able to "think". Although his thoughts are written in word bubbles rather than thought bubbles, it is generally assumed that the human characters cannot understand him. Once, in the early volume *Tintin in America*, Tintin was able to directly understand Snowy. Hergé did not elaborate on why this was so; presumably it was used simply to advance the plot and not to bog down the story with a "talking dog" element.

- The American television show Mr. Ed centers around a horse's ability to communicate with his owner, Wilbur. The plot of this television series was inspired by the movie character Francis the Talking Mule.

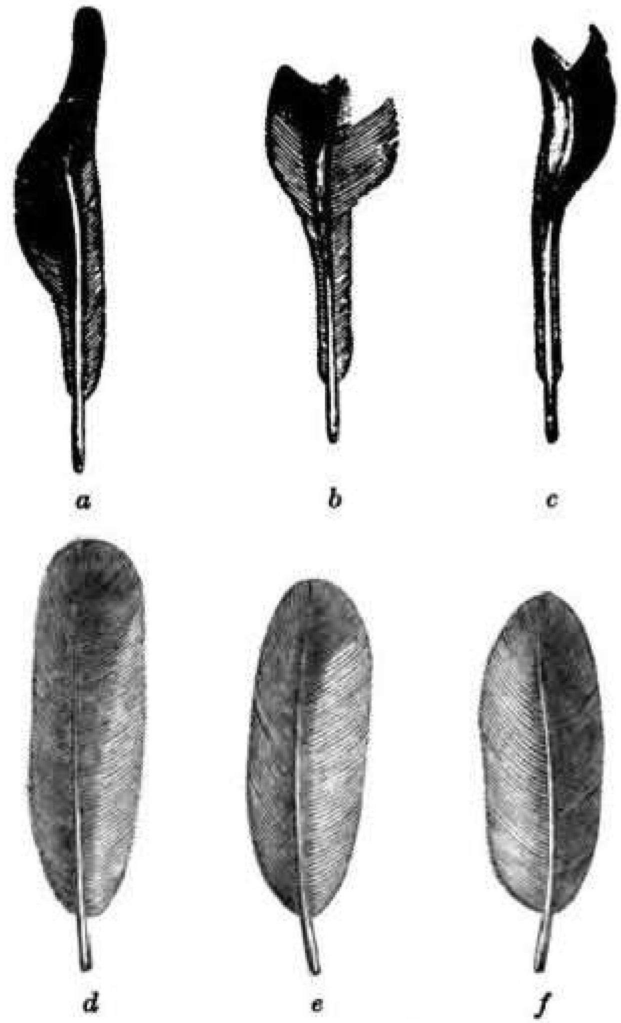
Chapter 15

Bird Vocalization

A male Blackbird (*Turdus merula*) singing. Bogense havn, Funen, Denmark.

Bird vocalization includes both bird calls and bird songs. In non-technical use, bird songs are the bird sounds that are melodious to the human ear. In ornithology and birding, (relatively complex) songs are distinguished by function from (relatively simple) calls.

Definition



Secondary wing-feathers of *Pipra deliciosa* (from Mr. Sclater, in Proc. Zool. Soc. 1860). The three upper feathers, *a, b, c*, from the male; the three lower corresponding feathers, *d, e, f*, from the female.

a. and *d.* Fifth secondary wing-feather of male and female, upper surface. *b* and *e.* Sixth secondary, upper surface. *c* and *f.* Seventh secondary, lower surface.

Wing feathers of a male Club-winged Manakin, with the modifications noted noted by P L Sclater in 1860 and discussed by Charles Darwin in 1871

The distinction between songs and calls is based upon complexity, length, and context. Songs are longer and more complex and are associated with courtship and mating, while calls tend to serve such functions as alarms or keeping members of a flock in contact. Other authorities such as Howell and Webb (1995) make the distinction based on function, so that short vocalizations such as those of pigeons and even non-vocal sounds such as the drumming of woodpeckers and the "winnowing" of snipes' wings in display flight are considered songs. Still others require song to have syllabic diversity and temporal regularity akin to the repetitive and transformative patterns which define music.

It is generally agreed upon in birding and ornithology which sounds are songs and which are calls, and a good field guide will differentiate between the two.

Bird song is best developed in the order Passeriformes. Most song is emitted by male rather than female birds. Song is usually delivered from prominent perches although some species may sing when flying. Some groups are nearly voiceless, producing only percussive and rhythmic sounds, such as the storks, which clatter their bills. In some manakins (Pipridae), the males have evolved several mechanisms for mechanical sound production, including mechanisms for stridulation not unlike those found in some insects.

The production of sounds by mechanical means as opposed to the use of the syrinx has been termed variously *instrumental music* by Charles Darwin, *mechanical sounds* and more recently *sonation*. The term *sonate* has been defined as the act of producing non-vocal sounds that are intentionally modulated communicative signals, produced using non-syringeal structures such as the bill, wings, tail, feet and body feathers.

Anatomy

The avian vocal organ is called the syrinx; it is a bony structure at the bottom of the trachea (unlike the larynx at the top of the mammalian trachea). The syrinx and sometimes a surrounding air sac resonate to sound waves that are made by membranes past which the bird forces air. The bird controls the pitch by changing the tension on the membranes and controls both pitch and volume by changing the force of exhalation. It can control the two sides of the trachea independently, which is how some species can produce two notes at once.

Function

Scientists hypothesize that bird song has evolved through sexual selection, and experiments suggest that the quality of bird song may be a good indicator of fitness. Experiments also suggest that parasites and diseases may directly affect song characteristics such as song rate, which thereby act as reliable indicators of health. The song repertoire also appears to indicate fitness in some species. The ability of male birds to hold and advertise territories using song also demonstrates their fitness.

Communication through bird calls can be between individuals of the same species or even across species. Birds communicate alarm through vocalizations and movements that are specific to the threat, and bird alarms can be understood by other animal species, including other birds, in order to identify and protect against the specific threat. Mobbing calls are used to recruit individuals in an area where an owl or other predator may be present. These calls are characterized by wide frequency spectra, sharp onset and termination, and repetitiveness which are common across species and are believed to be helpful to other potential "mobbers" by being easy to locate. The alarm calls of most species, on the other hand, are characteristically high-pitched making the caller difficult to locate.

Individual birds may be sensitive enough to identify each other through their calls. Many birds that nest in colonies can locate their chicks using their calls. Calls are sometimes distinctive enough for individual identification even by human researchers in ecological studies.

Many birds engage in duet calls. In some cases the duets are so perfectly timed as to appear almost as one call. This kind of calling is termed antiphonal duetting. Such duetting is noted in a wide range of families including quails, bushshrikes, babblers such as the scimitar babblers, some owls and parrots. In territorial songbirds, birds are more likely to countersing when they have been aroused by simulated intrusion into their territory. This implies a role in intraspecies aggressive competition.

Some birds are excellent vocal mimics. In some tropical species, mimics such as the drongos may have a role in the formation of mixed-species foraging flocks. Vocal mimicry can include conspecifics, other species or even man-made sounds. Many hypotheses have been made on the functions of vocal mimicry including suggestions that they may be involved in sexual selection by acting as an indicator of fitness, help brood parasites, protect against predation but strong support is lacking for any function. Many birds, and especially those that nest in cavities, are known to produce a snake like hissing sound that may help deter predators at close range.

Some cave-dwelling species, including Oilbird and Swiftlets (*Collocalia* and *Aerodramus* spp.), use audible sound (with the majority of sonic location occurring between 2 and 5 kHz) to echolocate in the darkness of caves. The only bird known to make use of infrasound (at about 20 Hz) is the western capercaillie.

The hearing range of birds is from below 50 Hz (infrasound) to above 20 kHz (ultrasound) with maximum sensitivity between 1 and 5 kHz. The range of frequencies at which birds call in an environment varies with the quality of habitat and the ambient sounds. It has been suggested that narrow bandwidths, low frequencies, low-frequency modulations, and long elements and inter-element intervals should be found in habitats with complex vegetation structures (which would absorb and muffle sounds) while high frequencies, broad bandwidth, high-frequency modulations (trills), and short elements and inter-elements may be expected in habitats with herbaceous cover. It has been hypothesized that the available frequency range is partitioned and birds call so that overlap between different species in frequency and time is reduced. This idea has been termed the "acoustic niche". Birds sing louder and at a higher pitch in urban areas, where there is ambient low-frequency noise.

Bird Language

The language of the birds has long been a topic for anecdote and speculation. That calls have meanings that are interpreted by their listeners has been well demonstrated. Domestic chickens have distinctive alarm calls for aerial and ground predators, and they respond to these alarm calls appropriately. However a language has, in addition to words, structures and rules. Studies to demonstrate the existence of language have been difficult due to the range of possible interpretations. Research on parrots by Irene Pepperberg is claimed to demonstrate the innate ability for grammatical structures, including the existence of concepts such as nouns, adjectives and verbs. Studies on starling vocalizations have also suggested that they may have recursive structures.

The term "bird language" may also more informally refer to patterns in bird vocalizations that communicate information to other birds or other animals in general. Wilderness Awareness School groups bird vocalizations into 5 different classes, sometimes called "voices," each of which communicates different information. Companion calling is a short vocalization made between mates, parent and young, or members of a flock to maintain contact when out of visual range. Juvenile begging is a strident, loud vocalization often made by young to a parent when begging for food. Intraspecific aggression can consist of loud, alarmed-sounding vocalizations or of energetic song, and may be heard when members of the same species behave aggressively toward each other. Alarm may be heard when birds are startled, frightened, or terrified for their lives, and can take many forms. Mobbing is one example of alarm, while a high-pitched alarm call is another.

Of the 5 voices of the birds, four of them communicate the message that the bird feels safe. Birds that engage in song, companion calling, juvenile begging, and intraspecific aggression all display what Jon Young calls "baseline" behavior, or a relaxed state free of the fear of predation. Alarm communicates the presence of a predator, or an influence that the bird may see as predatory such as a human hiker. Alarms have distinct sounds and shapes, each of which is specific to the source of the disturbance. For example, ravens mobbing a hawk or owl in a tree will clump around the predator in a loose ball, calling and diving. If the ravens rise off the tree and fly higher, the predator was a hawk and has flown up to escape, as is typical of hawks. If the ravens drop out of the tree and fly low and away, the predator was an owl and has dropped low off its perch to escape, as is typical of owls.

Neurophysiology

The main brain areas involved in bird song are:

- Anterior forebrain pathway (vocal learning): composed of the lateral part of the magnocellular nucleus of anterior neostriatum (LMAN), which is a homologue to mammalian basal ganglia); Area X, which is part of the basal ganglia; and the Dorso-Lateral division of the Medial thalamus (DLM).
- Song production pathway: composed of the HVC (sometimes, inaccurately, called the Hyperstriatum Ventralis pars Caudalis); robust nucleus of the arcopallium (RA); and the tracheosyringeal part of the hypoglossal nucleus (nXIIts).

Both pathways show sexual dimorphism, with the male producing song most of the time. It has been noted that injecting testosterone in non-singing female birds can induce growth of the HVC and thus production of song.

Birdsong production is generally thought to start at the nucleus uvaeformis of the thalamus with signals emanating along a pathway that terminates at the syrinx. The pathway from the thalamus leads to the interfacial nucleus of the nidopallium to the HVC, and then to RA, the dorso-lateral division of the medial thalamus and to the tracheosyringeal nerve.

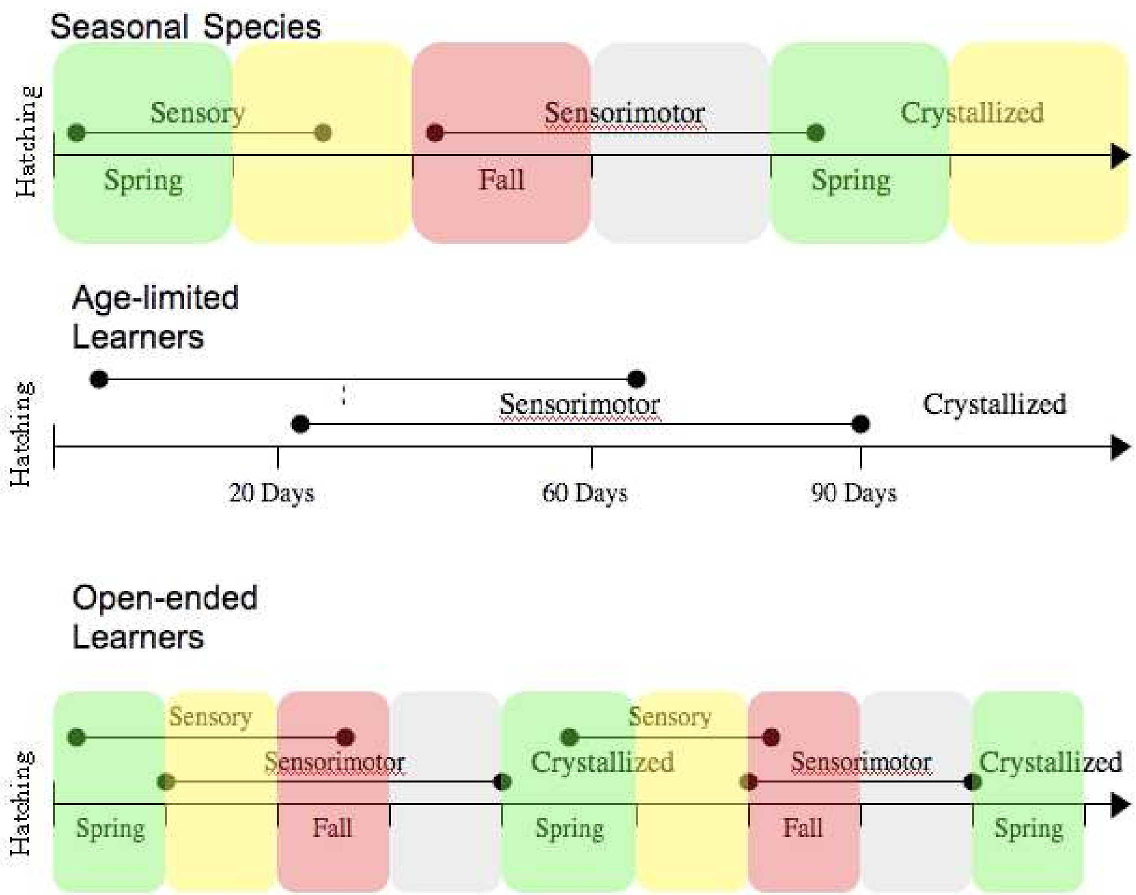
The gene FOXP2, defects of which affect both speech and comprehension of language in humans, becomes more active in the striatal region of songbirds during the time of song learning.

Recent research in birdsong learning has focused on the Ventral Tegmental Area (VTA), which sends a dopamine input to the para-olfactory lobe and Area X, LMAN and the ventrolateral medulla. Other researchers have explored the possibility that HVc is responsible for syllable production, while the robust nucleus of the arcopallium, the primary song output nucleus, may be responsible for syllable sequencing and production of notes within a syllable.

Learning

The songs of different species of birds vary, and are more or less characteristic of the species. In modern-day biology, bird song is typically analysed using acoustic spectroscopy. Species vary greatly in the complexity of their songs and in the number of distinct kinds of song they sing (up to 3000 in the Brown Thrasher); in some species, individuals vary in the same way. In a few species such as starlings and mockingbirds, songs imbed arbitrary elements learned in the individual's lifetime, a form of mimicry (though maybe better called "appropriation" [Ehrlich *et al.*], as the bird does not pass for another species). As early as 1773 it was established that birds learnt calls and cross-fostering experiments were able to force a Linnet *Acanthis cannabina* to learn the song of a skylark *Alauda arvensis*. In many species it appears that although the basic song is the same for all members of the species, young birds learn some details of their songs from their fathers, and these variations build up over generations to form dialects.

Birds learn songs early in life with sub-vocalizations that develop into renditions of adult songs. Zebra Finches, the most popular species for birdsong research, develop a version of a familiar adult's song after 20 or more days from hatch. By around 35 days, the chick will have learned the adult song. The early song is "plastic" or variable and it takes the young bird two or three months to perfect the "crystallized" song (which is less variable) of sexually mature birds.



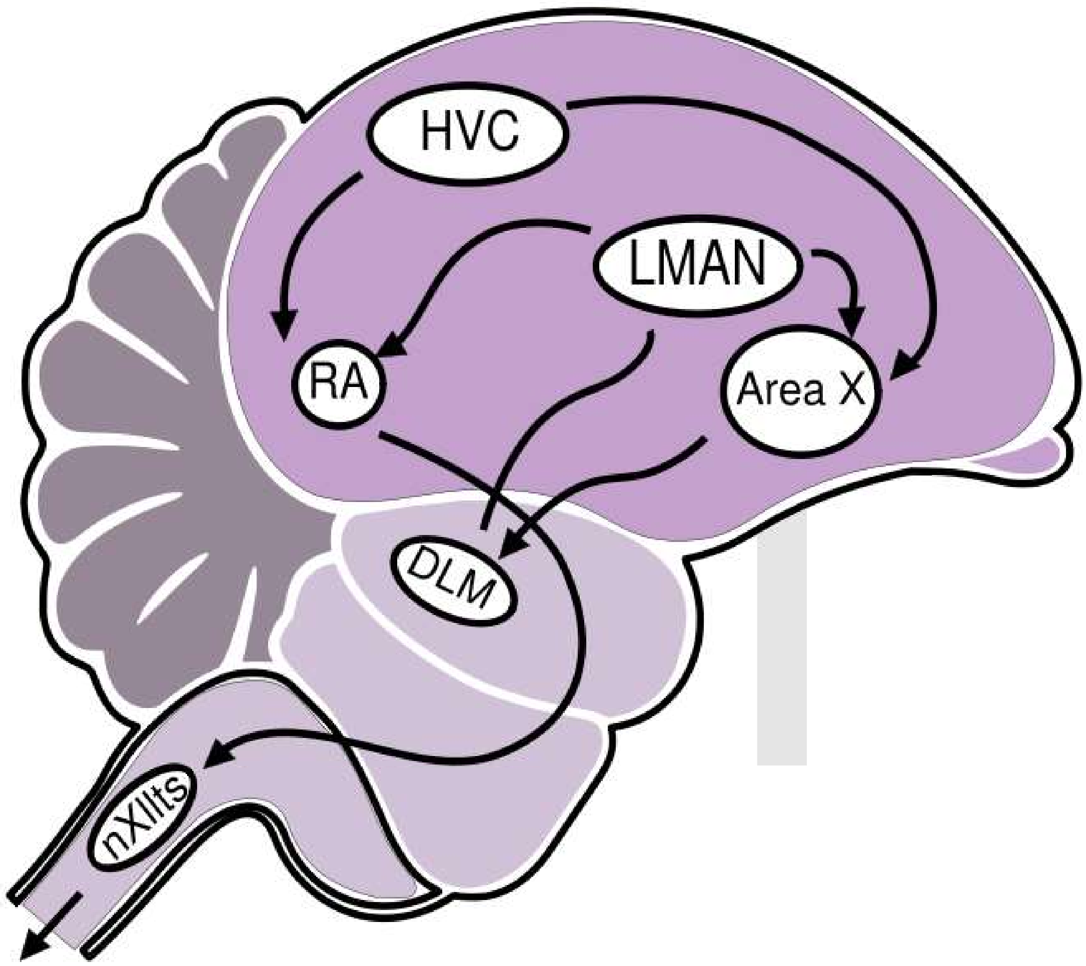
Timeline for song learning in different species. Diagram adapted from Brainard & Doupe, 2002.

Research indicates birds' acquisition of song is a form of motor learning that involves regions of the basal ganglia. Models of bird-song motor learning are sometimes used as models for how humans learn speech. In some species such as zebra finches, learning of song is limited to the first year; they are termed 'age-limited' or 'close-ended' learners. Other species such as the canaries can develop new songs even as sexually mature adults; these are termed 'open-ended' learners.

Researchers have hypothesized that learned songs allow the development of more complex songs through cultural interaction, thus allowing intraspecies dialects that help birds stay with their own kind within a species, and it allows birds to adapt their songs to different acoustic environments.

Auditory feedback in bird song learning

Early experiments by Thorpe in 1954 showed the importance of a bird being able to hear a tutor's song. When birds are raised in isolation, away from the influence of conspecific males, they still sing. While the song they produce resembles the song of a wild bird, it lacks the complexity and sounds distinctly different. The importance of the bird being able to hear himself sing in the sensorimotor period was later discovered by Konishi. Birds deafened before the song crystallization period went on to produce very different songs from the wild type. These findings led scientists to believe there could be a specific part of the brain dedicated to this specific type of learning.



Song learning pathway in birds (Based on Nottebohm, 2005)

The main focus in the search for the neuronal aspect of bird song learning was guided by the song template hypothesis. This hypothesis is the idea that when a bird is young he memorizes the song of his tutor. Later, during the development phase as an adult, he matches his own trial vocalizations using auditory feedback to an acoustic template in the brain. Based on this information, he adjusts his song if needed. To find this "song template," experimenters lesioned certain parts of the brain and observed the effects.

- Lesioning the song production pathway (RA, xXII or HVc) in the brain creates serious effects on song production in all birds.

- Lesions parts of the anterior forebrain pathway, or vocal learning pathway, DLM and area X, result in deficits in learning in all birds.
- Lesioning LMAN, located in the anterior forebrain pathway in young birds disrupts song production.
- Lesioning LMAN on an adult bird shows no effect.
- Lesioning LMAN on an adult canary (an "open-ended learner" species, which can learn songs later in life) shows a progressive deterioration of song.

These results show that the area known as LMAN is the only brain area in the pathway that shows some plasticity and further studies have shown that this area of the brain responds best to the bird's own song. This neuroplasticity is vital for a bird being able to learn a song. The ability to make small adjustments based on auditory feedback is needed for the complexity of these beautiful songs. Just like any musician, birds need to practice and be able to evaluate what their song sounds like and what it's supposed to sound like in order to get it right.

To complete the picture on bird song learning, experimenters needed to discover the true plasticity of the brain. While deafening and creating auditory isolation were good techniques for discovering basic characteristics about the brain, a reversible procedure was needed to investigate further. The solution was found in disruption of the auditory feedback, or what a bird hears. A computer is able to capture the song of a singing bird and play back portions of its song, or selectively play back a certain syllable while the bird is singing. The computer is basically playing the age old trick of repeating whatever the bird sings, the "stop copying me" game. This creates such a disruption that an adult bird will start to decrystallize its song, which includes a loss of spectral and temporal rigidity characteristic of adult song. It reverts back to the song it started singing with, before any learning took place. Furthermore, when the feedback was stopped, the birds slowly recovered their original song, something that was unheard of. These results show that there is a fair amount of plasticity retained in the brain, even for close-ended learners. This new found plasticity in adult birds and the results on the plasticity of LMAN (shown above) combine into a model for bird song learning (diagram coming soon).

Mirror neurons and vocal learning

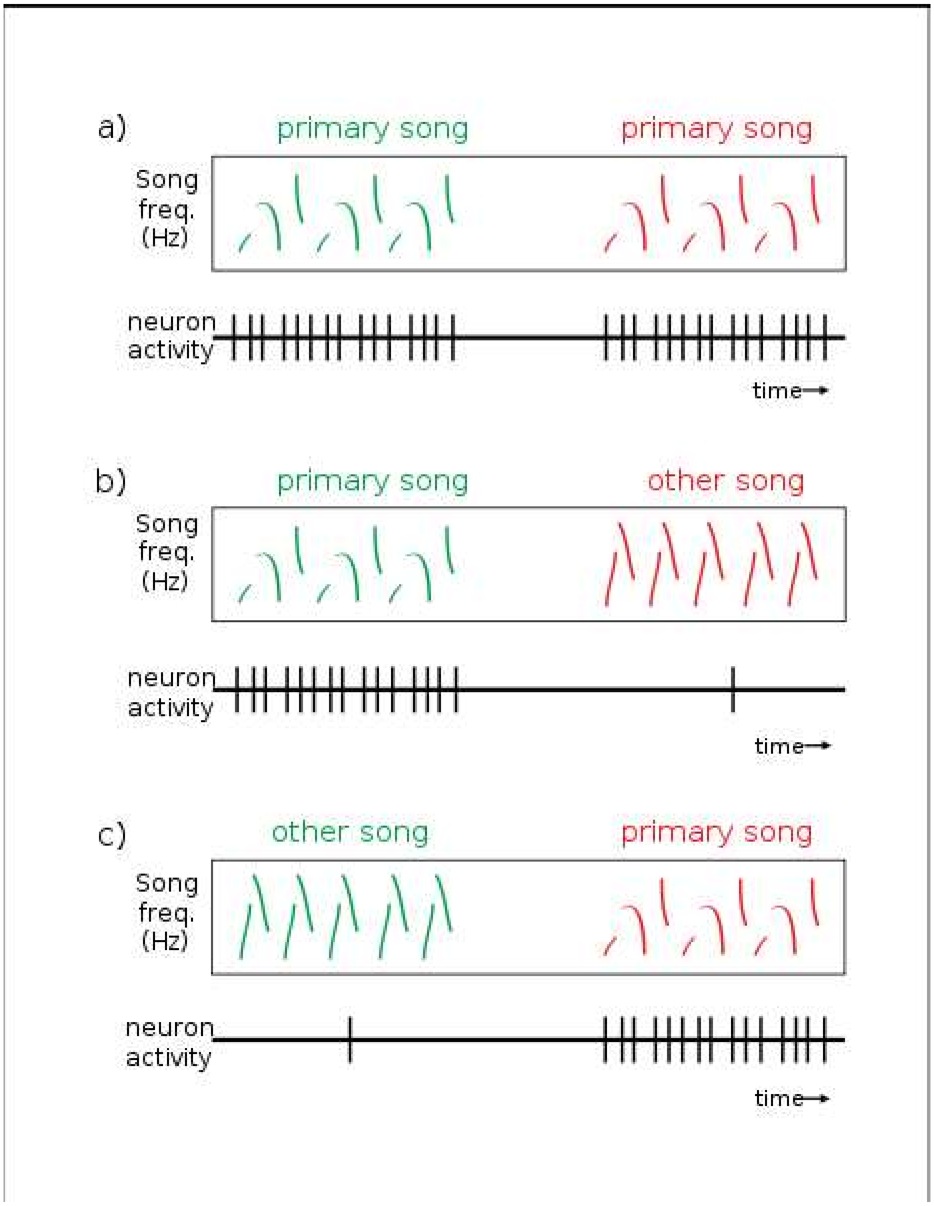
A mirror neuron is a neuron that discharges both when an individual performs an action, and when he perceives that same action being performed by another. These neurons were first discovered in macaque monkeys, but recent research suggests that mirror neuron systems may be present in other animals including humans.

Mirror neurons have the following characteristics:

- They are located the premotor cortex
- They exhibit both sensory and motor properties

- They are action-specific – mirror neurons are only active when an individual is performing or observing a certain type of action (e.g.: grasping an object).

Because mirror neurons exhibit both sensory and motor activity, some researchers have suggested that mirror neurons may serve to map sensory experience onto motor structures. This has implications for birdsong learning– many birds rely on auditory feedback to acquire and maintain their songs. Mirror neurons may be mediating this comparison of what the bird hears and what he produces.



Song selectivity in HVCx neurons: neuron activity in response to calls heard (green) and calls produced (red). **a.** Neurons fire when the primary song type is either heard or sung. **b,c.** Neurons do not fire in response to the other song type, regardless of whether it is heard or sung. Sketch based on figure from Prather et al. (2008)

In search of these auditory-motor neurons, Jonathan Prather and other researchers at Duke University recorded the activity of single neurons in the HVCs of swamp sparrows. They discovered that the neurons that project from the HVC to Area X (HVC_X neurons) are highly responsive when the bird is hearing a playback of his own song. These neurons also fire in similar patterns when the bird is singing that same song. Swamp sparrows employ 3-5 different song types, and the neural activity differs depending on which song is heard or sung. The HVC_X neurons only fire in response to the presentation (or singing) of one of the songs, the primary song type. They are also temporally selective, firing at a precise phase in the song syllable.

Because the timing of the neural response is identical regardless of whether the bird was listening or singing, how can we be sure that the bird isn't just hearing himself? Prather et al. found that during the short period of time before and after the bird sings, his HVC_X neurons become insensitive to auditory input. In other words, the bird becomes "deaf" to his own song. This suggests that these neurons are producing a corollary discharge, which would allow for direct comparison of motor output and auditory input. This may be the mechanism underlying learning via auditory feedback.

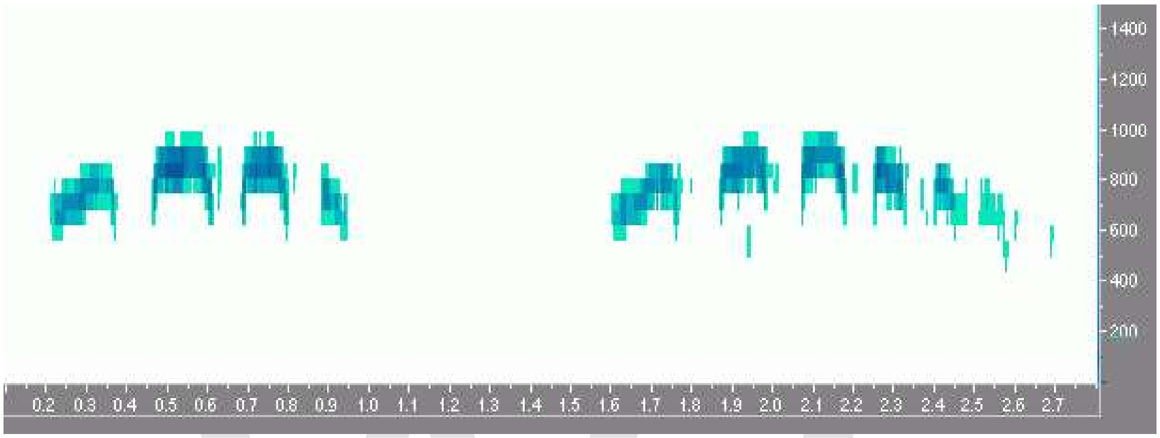
Overall, the HVC_X auditory-motor neurons in swamp sparrows are very similar to the visual-motor mirror neurons discovered in primates. Like mirror neurons, the HVC_X neurons:

- Are located in a premotor brain area
- Exhibit both sensory and motor properties
- Are action-specific – a response is only triggered by the 'primary song type'

The function of the mirror neuron system is still unclear. Some scientists speculate that mirror neurons may play a role in understanding the actions of others, imitation, theory of mind and language acquisition, though there is currently insufficient neurophysiological evidence in support of these theories. Specifically regarding birds, it is possible that the mirror neuron system serves as a general mechanism underlying vocal learning, but further research is needed. In addition to the implications for song learning, the mirror neuron system could also play a role in territorial behaviors such as song-type matching and countersinging.

Identification and systematics

The specificity of bird calls has been used extensively for species identification. The calls of birds have been described using words or nonsense syllables, or line diagrams. Common terms in English include words such as *quack*, *chirp* and *chirrup*. These are subject to imagination and vary greatly; a well-known example is the White-throated Sparrow's song, given in Canada as *O sweet Canada Canada Canada* and in New England as *Old Sam Peabody Peabody Peabody* (also *Where are you Frederick Frederick Frederick?*). In addition to nonsense words, grammatically correct phrases have been constructed as likenesses of the vocalizations of birds. For example, the Barred Owl produces a motif which some bird guides describe as *Who cooks for you? Who cooks for you all?* with the emphasis placed on *you*.



Sonogram of the call of a Laughing Dove.

The use of spectrograms to visualize bird song was first introduced by W. H. Thorpe. These visual representations are also called sonograms or sonagrams. Some recent field guides for birds use sonograms to document the calls and songs of birds. The sonogram is objective, unlike descriptive phrases, but proper interpretation requires experience. Sonograms can also be roughly converted back into sound.

Bird song is an integral part of bird courtship and is a pre-zygotic isolation mechanism involved in the process of speciation. Many allopatric sub-species show differences in calls. These differences are sometimes minute, often detectable only in the sonograms. Song differences in addition to other taxonomic attributes have been used in the identification of new species. The use of calls has led to proposals for splitting of species complexes such as those of the *Mirafra* Bushlarks.

Bird song and music

Some musicologists believe that birdsong has had a large influence on the development of music. Although the extent of this influence is impossible to gauge, it is sometimes easy to see some of the specific ways composers have integrated birdsong with music.

There seem to be three general ways musicians or composers can be affected by birdsong: they can be influenced or inspired (consciously or unconsciously) by birdsong, they can include intentional imitations of bird song in a composition, or they can incorporate recordings of birds into their works.

One early example of a composition that imitates birdsong is Janequin's "Le Chant Des Oiseaux", written in the 16th century. Other composers who have quoted birds or have used birdsong as a compositional springboard include Vivaldi (*Spring* from the *Four Seasons*)), Biber (*Sonata Representativa*), Beethoven (*Sixth Symphony*), Wagner (*Siegfried*) and the jazz musicians Paul Winter (*Flyway*) and Jeff Silverbush (*Grandma Mickey*).

The twentieth-century French composer Olivier Messiaen composed with birdsong extensively. His Catalogue d'Oiseaux is a seven-book set of solo piano pieces based upon birdsong. His orchestral piece *Réveil des Oiseaux* is composed almost entirely of birdsong. Many of his other compositions, including *Quatuor pour la fin du temps*, similarly integrate birdsong.

The Italian composer Ottorino Respighi, with his *The Pines of Rome* (1923–1924), may have been the first to compose a piece of music that calls for pre-recorded birdsong. A few years later, Respighi wrote *Gli Uccelli* ("The birds"), based on Baroque pieces imitating birds.

The Finnish composer Einojuhani Rautavaara in 1972 wrote an orchestral piece of music called *Cantus Arcticus* (Opus 61, dubbed *Concerto for Birds and Orchestra*) making extensive use of pre-recorded birdsongs from Arctic regions, such as migrating swans.

The American jazz musician Eric Dolphy sometimes listened to birds while he practiced flute. He claimed to have incorporated bird song into some of his improvisational music.

In the psychedelic era of the 1960s and 1970s, many rock bands included sound effects in their recordings. Birds were a popular choice. The English band Pink Floyd included bird sound effects in many of the songs from their 1969 albums *Soundtrack from the Film More* and *Ummagumma* (for example, Grantchester Meadows). Similarly, the English singer Kate Bush incorporated bird sound effects into much of the music on her 2005 album, Aerial.

The Music hall artist Ronnie Ronalde has gained notoriety for his whistling imitations of birds and for integrating birdsong with human song. His songs 'In A Monastery Garden' and 'If I Were A Blackbird' include imitations of the blackbird, his "signature bird."

The French composer François-Bernard Mâche has been credited with the creation of zoomusicology, the study of the music of animals. His essay *Musique, mythe, nature, ou les Dauphins d'Arion* (1983) includes a study of "ornitho-musicology", in which he speaks of "animal musics" and a longing to connect with nature.

The German DJ, techno music producer and naturalist Dominik Eulberg is an avid bird watcher, and several tracks by him prominently feature sampled bird sounds and even are titled after his favourite specimens.

The productions of The Jewelled Antler Collective often use field recordings featuring birdsong.

In 2007, The CT Collective issed two free albums devoted to music made using bird songs (one with human interaction, one without). The project was co-ordinated by looping musician Nick Robinson

Bird song and poetry

Bird song is a popular subject in poetry. Famous poems inspired by bird song include Percy Bysshe Shelley's To a Skylark ("Hail to thee, blithe Spirit!/Bird thou never wert") and Gerard Manley Hopkins' Sea and Skylark. Birdsongs and their relations to Middle-earth inhabitants are a common motif in J. R. R. Tolkien's literary work. The Grateful Dead performed a song called "Bird Song" that Jerry Garcia wrote and dedicated to Janis Joplin.

Chapter 16

Talking Bird

Talking birds are birds that can mimic human speech. Talking birds have varying degrees of intelligence and communication capabilities: some, like the crow, a highly intelligent bird, are only able to mimic a few words and phrases, whilst some budgerigars have been observed to have a vocabulary of almost two thousand words. The Hill Myna is a commonly kept pet, well known for its talking ability – whilst its relative, the European Starling, is also adept at mimicry.

Budgerigars

Puck

In 1995 a budgerigar named Puck was credited by Guinness World Records as having the largest vocabulary of any bird, at 1,728 words.

African Grey Parrots

The African Grey Parrots are particularly noted for their cognitive abilities. Some of the most notable African Grey Parrots are Alex, Prudle, N'kisi and a new rising star, Einstein.

Alex

Alex had a vocabulary of about 100 words, but he was one of the most famous birds because of his cognitive abilities. In 2005, World Science reported that Alex understood the concept of zero. Alex died on September 6, 2007.

Prudle

Prudle held the Guinness world record for bird with biggest vocabulary for many years with a documented vocabulary of 800 words.

N'kisi

N'kisi is noted for his impressive English usage skills and other abilities. As of January 2004, he had a documented vocabulary of 950 words and shows signs of a sense of humor. N'kisi is believed to be one of the most advanced users of human language in the animal world.

Einstein

Einstein appeared on many television shows and became famous for her ability to recreate sounds as well as voice. Video clips show her making the sound of a laser beam and an evil laugh. She has been trained by Stephanie White.

Sparky

African Grey Sparky is popular on YouTube for copying one liners from the sitcom *Still Game* in a broad Scottish accent.

Bibi

Bibi, a Congo African Grey Parrot, is best known for her ability to use greetings from 20 different languages, earning her the nickname "The Polyglot Parrot." At only three years of age, Bibi has already developed a vocabulary of about 300 words, and she understands the concepts of color and shape.

Amazon parrots

Many species of Amazona (particularly the yellow-head variety) are outstanding talkers. Yellow-napes, Double Yellow-headed, Yellow-crowned, and Panama Amazons are highly regarded as talking parrots.

Other parrots

Most parrot species are capable of imitating human words. Many can learn to use phrases in context; they can also be trained to imitate any words.

Hill Mynas

Hill Mynas are renowned for their ability to mimic the human voice. Many have claimed that the Hill Myna is the best talking bird and the best mimic in the world.

Chapter 17

Dog Communication

It is important to look at the dog's whole body and not just the mouth or tail before deciding what the dog is trying to communicate. What appears initially as aggression might be an invitation to play.

Dog communication refers to body movements and sounds dogs use to send signals to other dogs, and other animals (usually humans). Dog communication comes in a variety of forms, and is part of the foundation of dog social behavior. Dogs use certain movements of their bodies and body parts and different vocalizations to express their emotions. There are a number of basic ways a dog can communicate its feelings. These are movements of the ears, eyes, eyebrows, mouth, head, tail, and entire body, as well as barks, growls, whines and whimpers, and howls.

Interpreting animal body language

A dog might stretch after taking a nap, just as people do, or might drop into a stretch to lead into a play bow or to calm a person or other dog.

It is important to note that while many gestures and actions may have common, stereotypical meanings, researchers regularly find that animal communication is often more complex and subtle than previously believed, and that the same gesture may have multiple distinct meanings depending on context and other behaviors. So, generalizations such as "X means Y" are *often*, but not *always* accurate. For example, even a simple tail wag may (depending on context) convey many meanings including:

- Excitement
- Anticipation
- Playfulness
- Contentment/enjoyment
- Happiness, self-confidence

But also:

- Anxiety
- Uncertainty/apprehension

Combined with other body language, in a specific context, many gestures such as yawns and direction of vision all convey the dog's emotions or feeling states. Thus statements that a particular action "means" something, or that the dog is using its body language with the intent to report information to others, should be avoided. In *Consciousness Explained*, Daniel C. Dennett of Tufts University, tells us that there are two basic forms of communication: the unconscious expression of a mental or emotional state, and the intentional act of reporting information. He goes on to say that there are many ways of expressing a mental or emotional state, “but only one way of reporting information, and that is through the use of language, written, spoken, or signed.” It's also important to note that most of the body language exhibited by human beings isn't done consciously, with the intent to communicate, so it could be mistake to believe that dogs intentionally use their body language to report information to others.

Canine nose-to-anus greeting

Descriptions here are therefore best viewed as common generalizations, to which a more experienced observer will be able to add further detail or understanding.

Ethology is a science which studies animal behavior.

Greeting Ritual

One of the first forms of communication that will be observed is the greeting ritual. When a dog first encounters another dog, a brief assessment of aggression or friendliness is made. If one dog growls or barks, for instance, the encounter will usually end quickly, either by the other dog avoiding the encounter, or by a fight ensuing. If this test is passed, the dogs usually attempt to greet each other. This is done first by sniffing each other's odors. Dogs often sniff each other's rear-ends simultaneously, and this is the clearest indication of what some in the field believe to be a greeting ritual. This so-called greeting ritual is said to establish the identities of the dogs by scent, and is the dogs' way of saying 'hello' to each other. However, most people miss an important observation: even dogs who know each other very well will sniff one another when they first run into each other on the street. Dogs who live in multiple dog households will also sniff each other from time to time (for instance, if one dog gets up to get a drink of water while another dog is asleep, that dog might go over and sniff his housemate on his way to the water bowl). Dogs who are playing will sometimes get too wound up, stop, shake themselves off, then sniff each other before resuming their play session. So the idea that sniffing is just a greeting ritual is probably a misunderstanding.

If the dogs are satisfied with the encounter (it is not unusual for dogs to take a sudden dislike to each other at this stage), then they may either move on in disinterest, or proceed further in the greeting ritual by showing affection. Affection is shown by some or all of the following: Wagging the tail, licking the face, playful barking, panting, or jumping (including playful jumping on the other dog). Dogs that show affection in this way will usually get along fairly well, and this display can be considered a display of friendship.

Hand-sniff Greeting

Humans can also participate in a greeting ritual with a newly met dog, by bending down in front of (not looming over) or kneeling down to the dog, and slowly but confidently extending the hand to be sniffed in front of and just below the dog's snout. If the dog is timid or has a habit of snapping at strangers, it is best to allow the dog to come sniff your hand, rather than extending it into the dog's space (this can make the dog nervous) while using words of praise in a calm, soothing voice. To limit the chance of getting bitten, keep the hand palm-down with fingers cupped downward or the hand fully closed in a loose fist, making it difficult for the dog to grab hold of a finger in a bite. Be watchful of the dog's demeanor. If the dog makes a sudden snap at your hand, try not to pull it away as that will only reinforce and increase the dog's desire to bite you. Any object moving away from a dog triggers an instinctive urge to bite. However, if you continue praising the dog in a soothing voice, even if it's just snapped at you, the dog is much less likely to get frightened and will more than likely sniff your hand in a friendly manner.

After the dog has completed the hand-sniff, it is possible to proceed to making physical contact by gently petting the dog on its chest or shoulders. Attempting to pet the top of the head can create a nervous response because the movement of the hand toward the head may interrupt the dog's ability to see your eyes, thereby assessing your emotional state. Again, it is possible to get snapped at, so care should be taken not to block the dog's ability to see your eyes. If the dog does snap, the best course of action is not pull your hand away suddenly, but to keep praising the dog in a soothing tone. If the dog completes the sniff without snapping or barking, another attempt to pet the dog can be made.

Once the dog allows the affectionate petting, it will more likely only take a quick hand-sniff on the next meeting for the person to attempt petting the dog. Petting can at this time become more playful without risking the dog snapping at the person.

The dog is showing signs of fear aggression. Notice the lowered head, body down, foot pointing, raised back hair, ready to pounce hind legs and focused attention.

For timid or mildly aggressive dogs, it may not be possible to establish friendship in one greeting ritual. Friendship cannot be forced, and may require repeated attempts over time.

Caution against aggression during the greeting ritual

Some breeds of dog have a more suspicious or aggressive temperament by nature and are more difficult or dangerous to approach with the greeting ritual. Dogs that have been physically abused tend to be much more timid and defensive than a well-treated dog, so great care should be taken before trying to perform the greeting ritual with such a dog, as these dogs are more prone to react aggressively. Some dogs are also trained to be aggressive, such as guard dogs. A safer route to gaining the dog's trust would be to provide it with food, and to slowly acclimatise the dog to your presence. The best might be to avoid aggressive dogs altogether.

Dominance and submission

Dominance and submission are often mistaken to be part of normal social behaviors for dogs. They are not. Wild canines form packs specifically for the purpose of hunting large prey. Evolutionary biologist Raymond Coppinger has noted that wolves that live near garbage dumps, and therefore don't need to hunt large prey, don't form packs. He also states that coyotes, which are more solitary than wolves, sometimes form packs, but only when they need to hunt large prey. In Dog Language, biologist Roger Abrantes has noted that it's easier for a group of wolves to hunt large prey by working together. So pack formation in canines seems to be a function of prey size more than dominance and submission.

The idea that dogs exhibit dominant and submissive behaviors is based partly on behaviors seen in captive wolves that were culled from various sources, didn't know one another, and weren't able to hunt together. David Mech of the University of Minnesota has been studying wild wolf packs since the 1960s. Mech states that in wild packs "dominance" displays are so rare as to be totally nonexistent. The only time they seem to take place is when a conflict emerges between the pack parents over how to disburse food to the young. The female invariably wins these encounters by acting as "non-threatening" (or submissive) as possible. Rudolph Schenkel was the first biologist to ask the question, if the "submissive" wolf always wins, who's really dominant? Also, since "dominance aggression" in dogs can be treated with anti-anxietal medications, it's more likely that this behavior is an expression of stress or anxiety, and is not a natural part of the canine social instincts. (Mech (1999) asserted that the significance of dominance relationships within pack society has been overrated, and he argued that wolf packs are best understood as family groups in which a breeding pair "shares leadership in a division of labor system in which the breeding female initiates pup care and the breeding male leads in foraging and food provisioning". INTRODUCTION: "Leadership behavior in relation to dominance and reproductive status in gray wolves, Canis lupus," Rolf O. Peterson, Amy K. Jacobs, Thomas D. Drummer, L. David Mech, and Douglas W. Smith, *Canadian Journal of Zoology*, Vol. 80, 2002, p. 1406)

Body movements

Tail

How high or low the tail is held, in relation to how the dog's breed naturally carries its tail, and how it is moved can signify the dog's mood. When the tail is held high, it shows that the dog is alert; tail between the legs means that the dog is afraid. If the fur on the tail is also bristled, the dog is saying it is willing to defend.

Small, slow wags of the tail say the dog is questioning things around it. Either it is not sure whether the target dog or person is friendly, or it is not sure what is going on or what is expected of it.

Large, fast wags of the tail may be a sign of a happy or excited dog, but can also signal aggression. A large percentage of the victims of dog bites are bitten while the dog is wagging its tail.

Dogs are said to exhibit a left-right asymmetry of the tail when interacting with strangers, and will show the opposite, right-left motion with people and dogs they know.

Aggressive/ violent

These dogs are showing the major signs of aggression, but they are not fighting, so body language should not be inferred on isolated signs

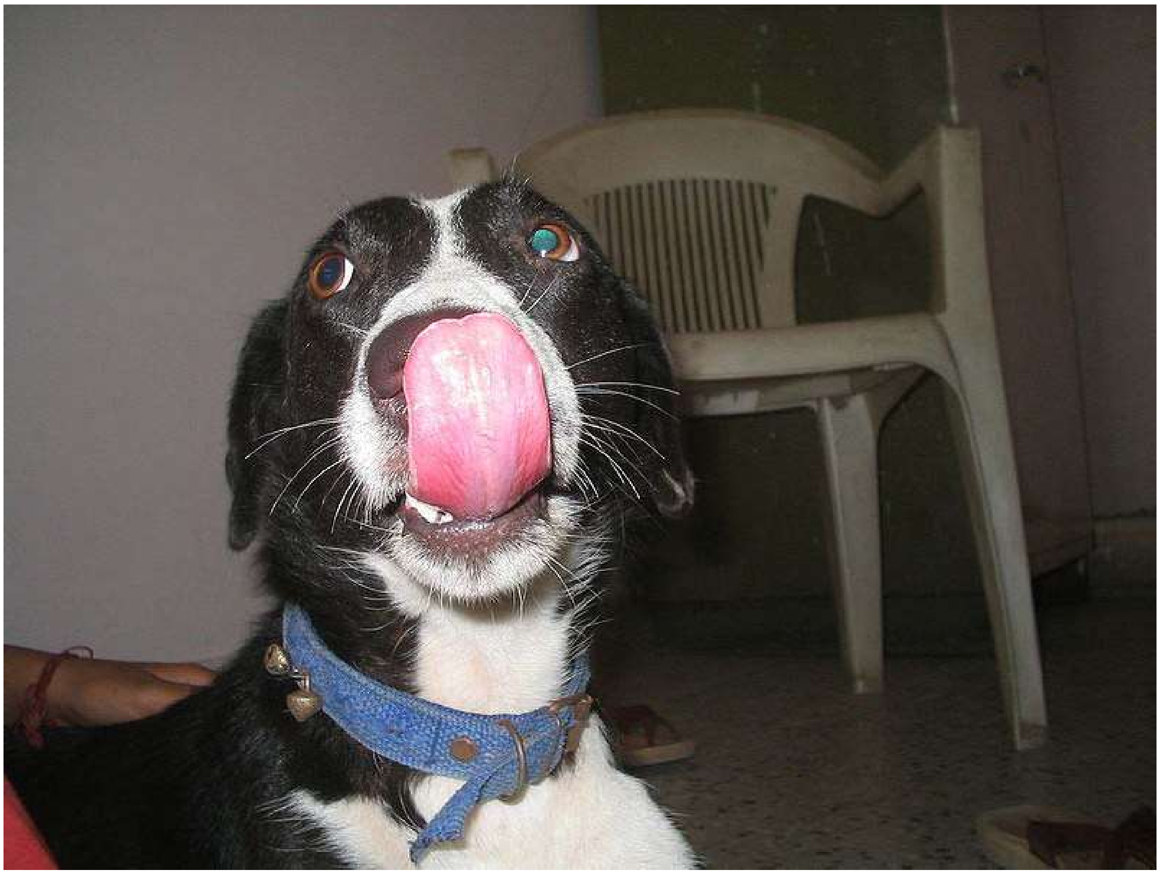
This dog is not "smiling" but feeling defensive about its bone.

When a dog's lips curl back this shows that the dog has a strong urge to bite. This is an unconscious reflex, designed to get the soft flesh of the lips away from the teeth before the dog bites, and is often misinterpreted as a way of communicating aggressive intent. For example, many dogs will curl their lips back into a "snarl" when they take a cookie or bone.

Ears

Ear position relates the dog's level of attention, and reaction, to a situation or animal. Erect ears facing forward means the dog is very attentive, while ears laid back suggests a negative, usually fearful or a timid reaction. They also lay their ears back for the sounds surrounding them. Dogs with drop ears, like Beagles, can't use these signals very well, as the signals first developed in wolves, whose ears are pricked. Wolf-like dogs (such as the Samoyed or Husky) will, when content and happy, often hold their ears in a horizontal position but still forward. This has been referred to as the "wolf smile".

Mouth



A dog showing all signs of being anxious - white half moon eyes, nose licking, sideways glance etc

Mouth expressions can provide information about the dog's mood. When a dog wants to be left alone, it might yawn (although yawning also might indicate sleepiness, confusion, or stress) or start licking its mouth without the presence of any food. When a dog is happy or wants to play, it might pant with lips relaxed, covering the teeth and with what sometimes appears to be a happy expression (it might appear as a smile to some observers) or with the mouth open. Mouth expressions that indicate aggression include the snarl, with lips retracting to expose the teeth, although some dogs also use this during play. However, some dogs will pull back their "top lips" in what looks like an aggressive way, when they are excited or happy. For example a dog prone to "smiling" may do so in greeting to a much loved owner and this should not be punished lest the dog become less affectionate and more withdrawn.

It's important to look at the dog's whole body and not just the mouth or tail before deciding what the dog is feeling. What appears initially as aggression might be an invitation to play, or vice-versa.

Tongue (Licking)

A very common form of communication is for a dog to lick another dog, or a person. Dogs lick other dogs' faces and mouths when they greet each other to indicate friendliness. Dogs like to lick human skin not only for the salt from the sweat, but also as a form of greeting, such as by briefly licking a person's hand after sniffing it. Licking is also used as a social bonding analogous to primate social grooming and stroking. This can indicate intimacy. Such licking is longer and slower, as compared to the brief licking of faces during a greeting.

Eyes and eyebrows

While dogs don't have actual eyebrows, they do have a distinctive ridge above their eyes, and some breeds, like the Labrador Retriever, Rottweiler, German Shepherd, and Doberman have markings there. A dog's eyebrow movements usually express a similar emotion to that of a human's eyebrow movements. Raised eyebrows suggest interest, lowered brows suggest uncertainty or mild anger, and one eyebrow up suggests bewilderment. Eyes narrowed to slits indicate affection for the person or animal the dog is looking at.

Feet and legs

Two dogs stamping their feet, maybe to gain attention.

Although a dog's feet lack the dexterity of human hands, a dog can use them as an avenue of communication. A dog might stamp its feet, alternating its left and right front legs, while its back legs are still. This occurs when the dog is excited, wants something, or wants its owner's attention. Pointers tend to tuck one front leg up when they sense game nearby. This behavior is not communicative so much as the dog exhibiting a fixed-action pattern called "the eye stalk." It is also common for dogs to paw or scratch for objects they desire. Many dogs are trained to mimic a human handshake, offering a paw to a human stooping down and offering their own hand in exchange.

Head

Leaning of head and forward ears on hearing the shutter sound of camera for the first time

The leaning of a dog's head to the right or to the left often indicates curiosity and/or a sound it has not heard before. This, however, may also be a sign of recognition to a familiar word.

If the dog's head is held high with its neck craning forward, it is showing interest, although, it could also mean an aggressive mood if other body language is present.

Some adult dogs that were not properly raised have been known to challenge their owners for alpha position. One of the signs, though this is rarely seen in dogs, involves the dog slightly lowering its head while standing tall with its eyes fixed upward at the owner or any human beings they are about to challenge (start a fight with). This behavior is extremely rare and usually occurs with dogs that have been severely neglected or in some cases, abused. This can also be dangerous and sometimes fatal if no action is taken immediately. However, this behavior is preventable if owners avoid being neglectful or abusive to their dogs.

Vocalizations

Barks

Dogs bark for many reasons, such as when perceived intruders (humans, dogs, or other animals) approach their living space, when hearing an unfamiliar or unidentified noise, when seeing something that the dog doesn't expect to be there, or when playing. Barking also expresses different emotions for a dog, such as loneliness, fear, suspicion, stress, and pleasure. Playful or excited barks are often short and sharp, such as when a dog is attempting to get a person or another dog to play.

Dogs generally try to avoid conflict; their vocalizations are part of what allows other dogs to tune into their emotions, i.e., whether they're aggressive or are in a playful mood.

The bark of a distressed or stressed dog is high pitched and repetitive; it tends to get higher in pitch as the dog becomes more upset. For example, a dog left home alone and who has separation anxiety might bark in such a way.

Some breeds of dogs have been bred to bark when chasing, such as scent hounds whose handlers use the bark to follow the dog if it has run out of sight. Coonhounds and bloodhounds are good examples. This kind of barking is often called "singing" as the sound is longer and more tonal.

Some research has suggested that dogs have separate barks for different animals, including dog, fox, deer, human, squirrel and cat.

Growls

Growls can express aggression, a desire to play, or simply that the dog doesn't want to participate in what's about to happen next (being picked up for example). For this reason, most pet owners have been urged to treat growls with special attention. This includes always considering the context of a growl, and exercise caution.

Howls

Howling may provide long-range communication with other dogs or owners. Howling can be used to locate another pack member, to keep strangers away, or to call the pack for hunting. Some dogs howl when they have separation anxiety.

Whines

Whining is a high-pitched vocalization, often produced nasally with the mouth closed. A dog may whine when it wants something (such as food), wants to go outside (possibly to 'go to the bathroom'), wants to be let off the leash (possibly to greet another dog or a person), or just wants attention. A very insistent dog may add a bark at the end of a whine, in a whine-bark, whine-bark pattern.

Whimpers

A whimper or a yelp often indicates the dog is in pain. This is often heard when dogs play-fight if one dog bites the other dog too hard. The whimper or yelp is used only when the dog intends to communicate its distress to a pack member (or human) to whom they are submissive or friendly, and the other dog or human is expected to react positively to the communication; dogs engaged in serious fights do not whimper, as this indicates weakness. Dogs also whimper when they are physically abused or neglected by people. Whimpers are often associated with the lowering of the tail between the legs. Whimpers can also indicate strong excitement when a dog is lonely and is suddenly met with affection, such as when a dog is left alone in a house during the day and its owner comes through the door late at night. Such whimpering is often accompanied by licking, jumping, and barking. Whimpering is distinct from barking in that it is softer, higher pitched, and lower volume.

Human speech

Though the phenomenon is often undiscussed, some dogs, followed by personal curiosities through observing the vocalization of the humans around them, may try to repeat human speech sounds, or are trained to do so. This kind of vocalization is typically achieved after lengthy training with positive reinforcement techniques. It's more likely that the dog is exhibiting these behaviors not because they "want" to communicate with humans, but is rather instead a previously reinforced behavior for a reward. Recent examples have included a whimpering pug on the *Late Show with David Letterman*.

Chapter 18

Ethology

A Blue Jay cracking nuts

Ethology is the scientific study of animal behavior, and a sub-topic of zoology.

Although many naturalists have studied aspects of animal behavior throughout history, the modern discipline of ethology is generally considered to have begun during the 1930s with the work of Dutch biologist Nikolaas Tinbergen and Austrian biologists Konrad Lorenz and Karl von Frisch, joint winners of the 1973 Nobel Prize in Physiology or Medicine. Ethology is a combination of laboratory and field science, with a strong relation to certain other disciplines — e.g., neuroanatomy, ecology, evolution. Ethologists are typically interested in a behavioral process rather than in a particular animal group and often study one type of behavior (e.g. aggression) in a number of unrelated animals.

The desire to understand animals has made ethology a rapidly growing topic, and since the turn of the 21st century, many prior understandings related to diverse fields such as animal communication, personal symbolic name use, animal emotions, animal culture, learning, and even sexual conduct long thought to be well understood, have been modified, as have new fields such as neuroethology.

Etymology

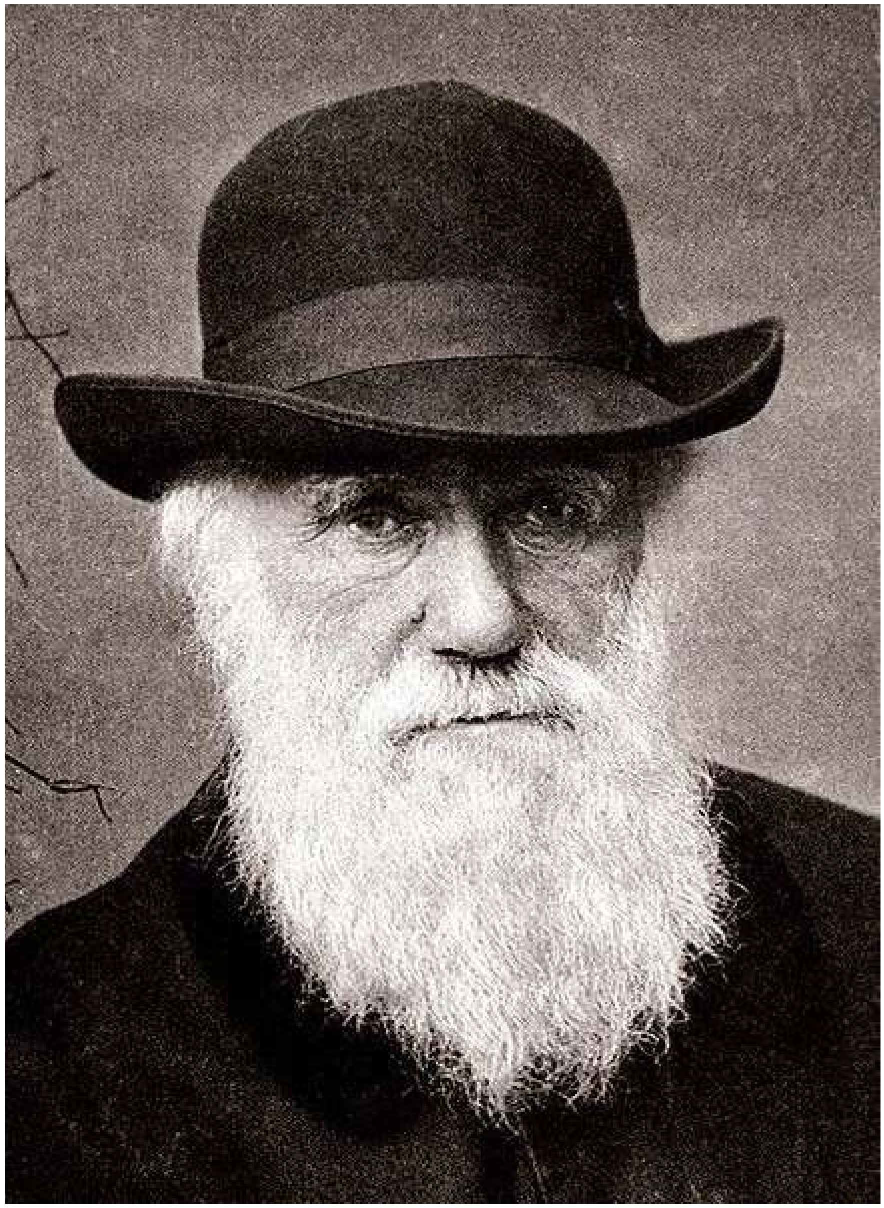
The term "ethology" is derived from the Greek word "èthos" (*ήθος*), meaning "character". Other words derived from the Greek word "ethos" include "ethics" and "ethical". The term was first popularized in English by the American myrmecologist William Morton Wheeler in 1902. (An earlier, slightly different sense of the term was proposed by John Stuart Mill in his 1843 *System of Logic*. He recommended the development of a new science, "ethology," the purpose of which would be explanation of individual and national differences in character, on the basis of associationistic psychology. This use of the word was never adopted.)

Differences and similarities with comparative psychology

Comparative psychology also studies animal behaviour, but, as opposed to ethology, is construed as a sub-topic of psychology rather than as one of biology. Historically, where comparative psychology researches animal behaviour in the context of what is known about human psychology, ethology researches animal behaviour in the context of what is known about animal anatomy, physiology, neurobiology, and phylogenetic history. This distinction is not representative of the current state of the field. Furthermore, early comparative psychologists concentrated on the study of learning and tended to research behaviour in artificial situations, whereas early ethologists concentrated on behaviour in natural situations, tending to describe it as instinctive. The two approaches are complementary rather than competitive, but they do result in different perspectives and, sometimes, in conflicts of opinion about matters of substance. In addition, for most of the twentieth century, comparative psychology developed most strongly in North America, while ethology was stronger in Europe. A practical difference is that early comparative psychologists concentrated on gaining extensive knowledge of the behaviour of very few species, while ethologists were more interested in gaining knowledge of behaviour in a wide range of species in order to be able to make principled comparisons across taxonomic groups. Ethologists have made much more use of a truly comparative method than comparative psychologists have. Despite the historical divergence, most ethologists (as opposed to behavioural ecologists), at least in North America, teach in psychology departments. It is a strong belief among scientists that the mechanisms on which behavioural processes are based are the same that cause the evolution of the living species: there is therefore a strong association between these two fields.

Scala naturae *and Lamarck's theories*

Jean-Baptiste Lamarck (1744–1829)



Charles Darwin (1809–1882)

Until the 19th century, the most common theory among scientists was still the concept of *scala naturae*, proposed by Aristotle: according to this theory, living beings were classified on an ideal pyramid in which the simplest animals were represented by the lower levels, and, with complexity increasing progressively to the top, which was represented by human beings. There was also a group of 'biologists' who refuted the Aristotelian theory for a more anthropocentric one, according to which all living beings were created by Buddha to serve mankind, and would behave accordingly. A well-radicated opinion in the common sense of the time in the Western world was that animal species were eternal and immutable, created with a specific purpose, as this seemed the only possible explanation for the incredible variety of the living beings and their surprising adaptation to their habitat.

The first biologist elaborating a complex theory of evolution was Jean-Baptiste Lamarck (1744–1829). His theory substantially comprised two statements: the first is that animal organs and behaviour can change according to the way they are being used, and second that those characteristics are capable of being transmitted from one generation to the next (well-known is the example of the giraffe whose neck becomes longer while trying to reach the upper leaves of a tree). The second statement is that each and every living organism, human beings included, tends to reach a greater level of perfection. At the time of his journey for the Galapagos Islands, Charles Darwin was well aware of Lamarck's theories and was influenced by them.

Theory of evolution by natural selection and the beginnings of ethology

Because ethology is considered a topic of biology, ethologists have been concerned particularly with the evolution of behaviour and the understanding of behaviour in terms of the theory of natural selection. In one sense, the first modern ethologist was Charles Darwin, whose book, *The Expression of the Emotions in Man and Animals*, influenced many ethologists. He pursued his interest in behaviour by encouraging his protégé George Romanes, who investigated animal learning and intelligence using an anthropomorphic method, anecdotal cognitivism, that did not gain scientific support.

Other early ethologists, such as Oskar Heinroth and Julian Huxley, instead concentrated on behaviours that can be called instinctive, or natural, in that they occur in all members of a species under specified circumstances. Their beginning for studying the behaviour of a new species was to construct an **ethogram** (a description of the main types of natural behaviour with their frequencies of occurrence). This provided an objective, cumulative base of data about behaviour, which subsequent researchers could check and supplement.

Fixed action patterns and animal communication

An important development, associated with the name of Konrad Lorenz though probably due more to his teacher, Oskar Heinroth, was the identification of fixed action patterns (FAPs). Lorenz popularized FAPs as instinctive responses that would occur reliably in the presence of identifiable stimuli (called **sign stimuli** or **releasing stimuli**). These FAPs could then be compared across species, and the similarities and differences between behaviour could be easily compared with the similarities and differences in morphology. An important and much quoted study of the Anatidae (ducks and geese) by Heinroth used this technique. Ethologists noted that the stimuli that released FAPs were commonly features of the appearance or behaviour of other members of their own species, and they were able to prove how important forms of animal communication could be mediated by a few simple FAPs. The most sophisticated investigation of this kind was the study by Karl von Frisch of the so-called "dance language" related to bee communication. Lorenz developed an interesting theory of the evolution of animal communication based on his observations of the nature of fixed action patterns and the circumstances in which animals emit them.

Instinct

Kelp Gull chicks peck at red spot on mother's beak to stimulate regurgitating reflex.

The Merriam-Webster dictionary defines instinct as a largely inheritable and unalterable tendency of an organism to make a complex and specific response to environmental stimuli without involving reason. For ethologists, instinct means a series of predictable behaviors for fixed action patterns. Such schemes are only acted when a precise stimulating signal is present. When such signals act as communication among members of the same species, they are known as releasers. Notable examples of releasers are, in many bird species, the beak movements by the newborns, which stimulates the mother's regurgitating process to feed her offspring. Another well known case is the classic experiments by Tinbergen on the Graylag Goose. Like similar waterfowl, it will roll a displaced egg near its nest back to the others with its beak. The sight of the displaced egg triggers this mechanism. If the egg is taken away, the animal continues with the behaviour, pulling its head back as if an imaginary egg is still being maneuvered by the underside of its beak. However, it will also attempt to move other egg shaped objects, such as a giant plaster egg, door knob, or even a volleyball back into the nest. Such objects, when they exaggerate the releasers found in natural objects, can elicit a stronger version of the behavior than the natural object, so that the goose will ignore its own displaced egg in favor of the giant dummy egg. These exaggerated releasers for instincts were termed supernormal stimuli by Tinbergen. Tinbergen found he could produce supernormal stimuli for most instincts in animals, such as cardboard butterflies which male butterflies preferred to mate with if their stripes were darker than a real female or dummy fish which a territorial male stickleback fish would fight more violently than a real invading male if the dummy had a brighter colored underside. Harvard psychologist Deirdre Barrett has done research pointing out how easily humans also respond to supernormal stimuli for sexual, nurturing, feeding, and social instincts. However, a behaviour only made of fixed action patterns would be particularly rigid and inefficient, reducing the probabilities of survival and reproduction, so the learning process has great importance, as the ability to change the individual's responses based on its experience. It can be said that the more the brain is complex and the life of the individual long, the more its behaviour will be "intelligent" (in the sense of guided by experience rather than stereotyped FAPs).

Learning

Learning occurs in many ways, one of the most elementary being habituation. This process consists in ignoring persistent or useless stimuli. An example of learning by habituation is the one observed in squirrels: when one of them feels threatened, the others hear its signal and go to the nearest refuge. However, if the signal comes from an individual who has caused many false alarms, its signal will be ignored.

Another common way of learning is by association, where a stimulus is, based on the experience, linked to another one which may not have anything to do with the first one. The first studies of associative learning were made by Russian physiologist Ivan Pavlov. An example of associative behaviour is observed when a common goldfish goes close to the water surface whenever a human is going to feed it, or the excitement of a dog whenever it sees a collar as a prelude for a walk. The associative learning process is related to the necessity of developing discriminatory capacities, that is, the faculty of making meaningful choices. Being able to discriminate the members of your own species is of fundamental importance for reproductive success. Such discrimination can be based on a number of factors in many species including birds, however, this important type of learning only takes place in a very limited period of time. This kind of learning is called imprinting.

Imprinting

Example of imprinting in a moose

A second important finding of Lorenz concerned the early learning of young nidifugous birds, a process he called imprinting. Lorenz observed that the young of birds such as geese and chickens followed their mothers spontaneously from almost the first day after they were hatched, and he discovered that this response could be imitated by an arbitrary stimulus if the eggs were incubated artificially and the stimulus was presented during a **critical period** (a less temporally constrained period is called a **sensitive period**) that continued for a few days after hatching.

Imitation

Finally, imitation is often an important type of learning. A well-documented example of imitative learning is that of macaques in Hachijojima island, Japan. These primates used to live in the inland forest until the 1960s, when a group of researchers started giving them some potatoes on the beach: soon they started venturing onto the beach, picking the potatoes from the sand, and cleaning and eating them. About one year later, an individual was observed bringing a potato to the sea, putting it into the water with one hand, and cleaning it with the other. Her behaviour was soon imitated by the individuals living in contact with her; when they gave birth, they taught this practice to their young.

The National Institutes of Health recently reported that capuchin monkeys preferred the company of researchers who imitated them to that of researchers who did not imitate them. The monkeys not only spent more time with their imitators, but also preferred to engage in a simple task with them even when provided with the option of performing the same task with a non-imitator.

Mating and the fight for supremacy

Individual reproduction is the most important phase in the proliferation of individuals or genes within a species: for this reason, we can often observe complex mating rituals, which can be very complex even if they are often regarded as fixed action patterns **(FAPs)**. The Stickleback's complex mating ritual was studied by Niko Tinbergen and is regarded as a notable example of a FAP. Often in social life, animals fight for the right of reproducing themselves as well as social supremacy.

A common example of fight for social and sexual supremacy is the so-called pecking order among poultry. A pecking order is established every time a group of poultry co-lives for a certain amount of time. In each of these groups, a chicken is dominating among the others and can peck before anyone else without being pecked. A second chicken can peck all the others but the first, and so on. The chicken in the higher levels can be easily distinguished for their well-cured aspect, as opposed to the ones in the lower levels. During the period in which the pecking order is establishing, frequent and violent fights can happen, but once it is established it is only broken when other individuals are entering the group, in which case the pecking order has to be established from scratch.

Living in groups

Several animal species, including humans, tend to live in groups. Group size is a major aspect of their social environment. Social life is probably a complex and effective survival strategy. It may be regarded as a sort of symbiosis among individuals of the same species: a society is composed of a group of individuals belonging to the same species living within well-defined rules on food management, role assignments and reciprocal dependence.

The situation is actually much more complex than it seems. When biologists interested in evolution theory first started examining social behaviour, some apparently unanswerable questions occurred. How could, for instance, the birth of sterile castes, like in bees, be explained through an evolving mechanism which emphasizes the reproductive success of as many individuals as possible? Why, among animals living in small groups like squirrels, would an individual risk its own life to save the rest of the group? These behaviours may be examples of altruism. Of course, not all behaviours are altruistic, as indicated by the table below. Notably, revengeful behaviour was at one point claimed to have been observed exclusively in *Homo sapiens*. However other species have been reported to be vengeful, including reports of vengeful camels and vengeful chimpanzees.

Classification of social behaviours

Type of behaviour	Effect on the donor	Effect on the receiver
Egoistic	Increases fitness	Decreases fitness
Cooperative	Increases fitness	Increases fitness
Altruistic	Decreases fitness	Increases fitness
Revengeful	Decreases fitness	Decreases fitness

The existence of egoism through natural selection doesn't pose any question to evolution theory and is, on the contrary, fully predicted by it, as well as for the cooperative behaviour. It is more difficult to understand the mechanism through which the altruistic behaviour initially developed.

Tinbergen's four questions for ethologists

Lorenz's collaborator, Niko Tinbergen, argued that ethology always needed to include four kinds of explanation in any instance of behaviour:

- Function — How does the behaviour affect the animal's chances of survival and reproduction? Why does the animal respond that way instead of some other way?
- Causation — What are the stimuli that elicit the response, and how has it been modified by recent learning?
- Development — How does the behaviour change with age, and what early experiences are necessary for the behaviour to be displayed?
- Evolutionary history — How does the behaviour compare with similar behaviour in related species, and how might it have begun through the process of phylogeny?

These explanations are complementary rather than mutually exclusive - all instances of behaviour require an explanation at each of these four levels. For example, the function of eating is to acquire nutrients (which ultimately aids survival and reproduction), but the immediate cause of eating is hunger (causation). Hunger and eating are evolutionarily ancient and are found in many species (evolutionary history), and develop early within an organism's lifespan (development). It is easy to confuse such questions - for example to argue that people eat because they're hungry and not to acquire nutrients - without realizing that the reason people experience hunger (causation) is because it causes them to acquire nutrients (function).

Growth of the field

By the work of Lorenz and Tinbergen, ethology developed strongly in continental Europe during the years prior to World War II. After the war, Tinbergen moved to the University of Oxford, and ethology became stronger in the UK, with the additional influence of William Thorpe, Robert Hinde, and Patrick Bateson at the Sub-department of Animal Behaviour of the University of Cambridge, located in the village of Madingley. In this period, too, ethology began to develop strongly in North America.

Lorenz, Tinbergen, and von Frisch were jointly awarded the Nobel Prize in Physiology or Medicine in 1973 for their work of developing ethology.

Ethology is now a well recognised scientific discipline, and has a number of journals covering developments in the subject, such as the Ethology Journal. In 1972, the International Society for Human Ethology was founded to promote exchange of knowledge and opinions concerning human behavior gained by applying ethological principles and methods and published in their journal, The Human Ethology Bulletin. During 2008, in a paper published in the journal Behaviour, ethologist Peter Verbeek introduced the term "Peace Ethology" as a sub-discipline of Human Ethology that is concerned with issues of human conflict, conflict resolution, reconciliation, war, peacemaking, and peacekeeping behavior.

Social ethology and recent developments

During 1970, the English ethologist John H. Crook published an important paper in which he distinguished **comparative ethology** from **social ethology**, and argued that much of the ethology that had existed so far was really comparative ethology—examining animals as individuals—whereas in the future ethologists would need to concentrate on the behaviour of social groups of animals and the social structure within them.

Also in 1970, Robert Ardrey's book *The Social Contract: A Personal Inquiry into the Evolutionary Sources of Order and Disorder* was published. The book and study investigated animal behaviour and then compared human behaviour as a similar phenomenon.

Indeed, E. O. Wilson's book *Sociobiology: The New Synthesis* appeared in 1975, and since that time the study of behaviour has been much more concerned with social aspects. It has also been driven by the stronger, but more sophisticated, Darwinism associated with Wilson, Robert Trivers and William Hamilton. The related development of behavioural ecology has also helped transform ethology. Furthermore, a substantial rapprochement with comparative psychology has occurred, so the modern scientific study of behaviour offers a more or less seamless spectrum of approaches – from animal cognition to more traditional comparative psychology, ethology, sociobiology and behavioural ecology. Sociobiology has more recently developed into evolutionary psychology.

Chapter 19

Bee Learning and Communication

Honey bees learn and communicate in order to find food sources and for other means.

Swarming bees require good communication in order to congregate all in the same spot

Learning

Learning is essential for efficient foraging. Honey bees are unlikely to make many repeat visits if a plant provides little in the way of reward. A single forager will visit different flowers in the morning and, if there is sufficient attraction and reward in a particular kind of flower, she will make visits to that type of flower for most of the day, unless the plants stop producing reward or weather conditions change. Honey bees are quite adept at associative learning, and many of the standard phenomena of classical conditioning take the same form in honey bees as they do in the vertebrates that are the more usual subjects of such experiments.

Foragers were trained to enter a simple Y-shaped maze that had been marked at the entrance with a particular color. Inside the maze was a branching point where the bee was required to choose between two paths. One path, which led to the food reward, was marked with the same color that had been used at the entrance to the maze, while the other was marked with a different color. Foragers learned to choose the correct path, and continued to do so when a different kind of marker (black and white stripes oriented in various directions) was substituted for the colored markers. When the experimental conditions were reversed, rewarding bees for choosing the inner passage marked with a symbol that was different from the entrance symbol, the bees again learned to choose the correct path. Extending the length of the tunnel to increase the time between seeing the one marker indicating the correct path and a second marker identifying the correct path show that the bees can retain the information in their visual working memory for about 5 seconds, equivalent to the short-term memory of birds.

Color Learning in Honeybees

One of the most common ways that honey bees, *Apis mellifera*, demonstrate associative learning is in the context of color recognition and discrimination tasks. Just as vertebrate species such as mice or pigeons that can be trained to perform associative learning tasks, honey bees make excellent subjects for tasks involving discrimination and color memory. Beginning in the early 1900s, scientists Karl von Frisch and later Randolf Menzel began asking questions about the existence, learning rates, memory, and timing of color vision in bees.

Color Discrimination

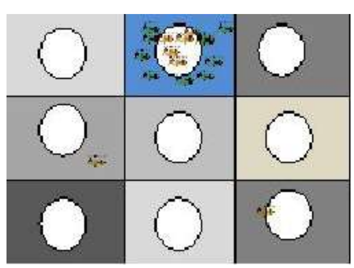


Figure 1. Testing for color vision in honey bees. The majority of bees flew directly to the dish with the blue background as they had been trained to do. Thus, they were able to

discriminate between gray and blue backgrounds, showing their capability for color vision.

The Austrian zoologist Karl von Frisch began the exploration of color vision in honey bees when he asked the first question in 1919: does color vision in bees exist? By making use of bees associative learning abilities he performed an elegant experiment to show that honey bees were in fact capable of color discrimination.

To test color vision, von Frisch first trained his honey bees to feed from a small dish filled with a nectar-like sugar water. This dish was placed over a small piece of blue colored cardboard so that the color was visible to the bees as they fed. Once the bees had become accustomed to the blue cardboard, von Frisch surrounded the blue piece of cardboard with other identically sized pieces in varying shades of gray and placed small dishes over each piece. If bees could not discriminate between colors, they would be unable to distinguish the blue piece from the many gray toned pieces. In the case that bees did not have color vision then, von Frisch predicted that the bees would visit the gray and blue pieces with equal frequency, as they would not be able to tell a difference between them.

When he allowed bees access to the dishes, however, he found that the vast majority of the bees flew directly to the blue piece of cardboard on which they had previously obtained their sugar-water reward. The bees largely ignored the gray pieces which had not been rewarded. This directed exploration and targeting of the blue cardboard showed the bees could indeed discriminate between the gray and blue shades, showing that bees do possess color vision. Von Frisch repeated this same basic experiment to show that bees produced the same results with other colors like red and yellow. Later other researchers were able to apply this excellent experimental design to other vertebrates as well, making it an invaluable insight into testing color vision in many organisms.

Color Learning Rates and Preferences

After von Frisch's initial studies, the German scientist Randolf Menzel continued the study of color vision in honey bees and performed more detailed tests. He was curious about which colors honey bees would be able to learn fastest and whether or not bees had a greater aptitude for learning certain colors.

He used lights of varying color and intensity to illuminate circles of light on a solid surface. This set up was similar to the pieces of colored cardboard employed by von Frisch, but by using light instead of cardboard, Menzel was able to change the intensity and color of light easily. He could simply adjust the projection of the light to create a wide variety of different experimental set-ups.

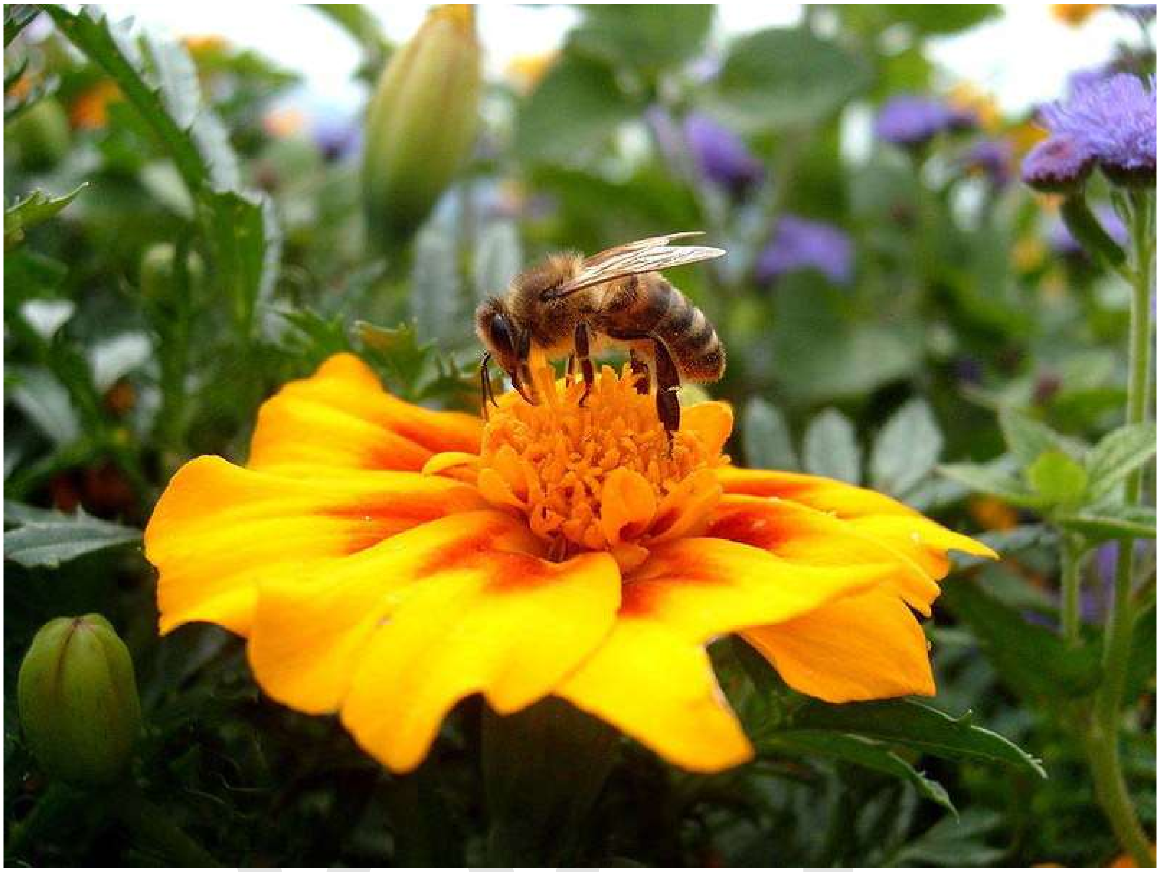


Figure 2. Honey bee collecting pollen

To test the intricacies of the bee color vision von Frisch had established, Menzel performed an experiment that aimed to test bees ability to distinguish between two different colors. To do this, Menzel used a projected circle of colored light surrounding a small dish that could hold a sugar-water reward. Menzel then projected a second circle of differently colored light surrounding a second dish some distance away from the first. Next, a single bee was placed equidistant between these two different lights and allowed to choose which dish to search for a sugar-water treat. Only one of the colored light circles surrounded a dish that contained sugar-water; the other was empty. Menzel was then able to measure how quickly the bees learned to preferentially search only the rewarded light and to ignore the dish surrounded by unrewarded light.

Interestingly, the results of the experiment showed that bees did not learn to discriminate between all color pairs equally well. The fastest rate of learning was when violet light was rewarded. The color that the bees had the most difficulty learning was green, and all other colors fell somewhere in between. This evidence of inherent bias is evolutionarily reasonable given that color vision in bees allows them to distinguish between different nectar-bearing flowers, much like the rewarded dishes. As more flowers are purple than green it makes sense that bees would be more sensitive to colors likely to result in nourishment.

Color Memory

After this work on color preferences, Menzel extended his experiments to study memory in honey bee color vision. He wanted to know how many trials were necessary for honey bees to reliably choose a previously rewarded color when presented with several choices for potential rewards and how long honey bees could retain information about which color would be rewarded.

To test these questions, Menzel performed a variety of experiments. First, he presented individual bees with a sugar reward on a colored background for just a single trial. He then kept these bees in small cages for several days without any further trials. After a few days, he presented each bee with several dishes each on a different colored background at once. One of the colors was the same as that used during the initial trial. The others were novel, unrewarded colors. Amazingly, after just one trial and several days without any exposure to the rewarded color, bees correctly chose to explore the color used in the first trial more than fifty-percent of the time.

Menzel then repeated this experiment with another group of bees, keeping all factors the same except that in the second round of testing he gave the bees three initial trials with the rewarded color instead of just one. After several days in confinement when the bees were presented with a choice of colors just as in the first experiment, they virtually always chose the color that had been used during the first three trials.

This ability to retain information about color-linked rewards over a period of several days and after only very minimal exposure to the colored background indicates the great strength of honeybees memory with respect to color vision.

Timing in Color Learning

One of von Frisch's students, Elizabeth Opfinger, observed that bees would learn color when approaching a feeder. Menzel took this question further: when do bees register and learn color? He wanted to know if bees registered color before, during, or after receiving their sugar-water reward. In order to explore this intriguing question, Menzel displayed the color beneath a rewarded dish at different stages of the honey bee feeding process: during approach, feeding and departure.

The outcome of this experiment revealed that bees register color during both the approach and feeding stages of the exposure process. In order for a bee to accurately remember a given color, it must be present for approximately five seconds in total. Although it varies slightly, Menzel and his colleagues found that bees usually remember best when the stimulus is present for about three seconds during the approach and two seconds after landing and beginning to feed.

The Neurobiology of Color Vision

Figure 3. Western Honey Bee

Color vision in honey bees can also be examined from a neurobiological perspective in terms of the structure and organization of their compound eyes.

In 1975 Menzel published a seminal paper describing the morphology and spectral sensitivity of the honey bee eye. He examined color coding the honey bee retina by using a technique to mark individual cells with a fluorescent dye and record from these cells as single units. Such fine structure analysis allowed him to determine that there are three types of receptors in the honey bee eye: 1) UV receptors, 2) blue receptors, and 3) green receptors. The three receptors are dominated by three rhodopsin-like pigments. These pigments have maximal absorbance at wavelengths corresponding to 350 nm, 440 nm, and 540 nm.

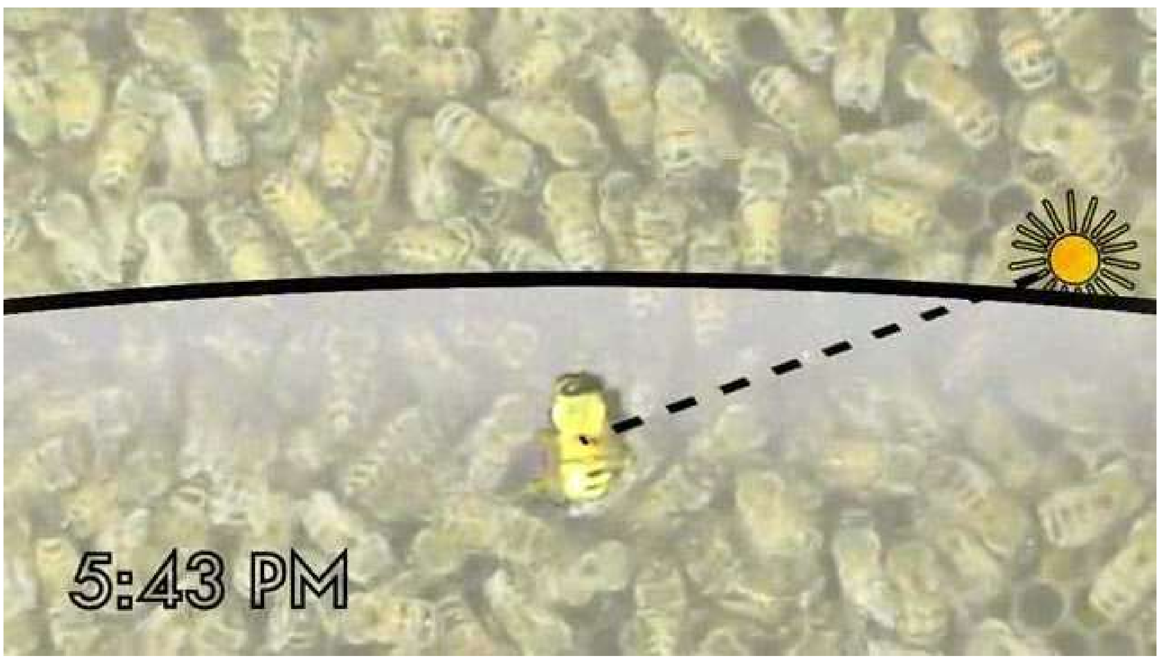
As the cells were examined in detail, certain features were distinguishable for each type of receptor cell. UV cells were found to form the longest visual fibres. These long visual fibers penetrated the lamina with arborizations, a tree-like branching of the fibers and spines. Blue and green receptor cells have more shallow fibers.

Interestingly, Menzel found that most of the cells he studied had secondary sensitivities that corresponded to wavelength regions at which the other two receptor types were maximally active. He used spectral efficiency experiments to show that such corresponding wavelength receptivity is the result of electric coupling.

Communication

Foragers communicate their floral findings in order to recruit other worker bees of the hive to forage in the same area. The factors that determine recruiting success are not completely known but probably include evaluations of the quality of nectar and/or pollen brought in.

There are two main hypotheses to explain how foragers recruit other workers — the "waggle dance" or "dance language" theory and the "odor plume" theory. The dance language theory is far more widely accepted, and has far more empirical support. The theories also differ in that the former allows for an important role of odor in recruitment (i.e., effective recruitment relies on dance *plus* odor), while the latter claims that the dance is essentially irrelevant (recruitment relies on odor alone).



The Waggle Dance of the Honeybee

It has long been known that successfully foraging Western honey bees perform a dance on their return to the hive, known as *waggle dance*, indicating that food is farther away, while the *round dance* is a short version of the *waggle dance*, indicating that food is nearby. The laden forager dances on the comb in a circular pattern, occasionally crossing the circle in a zig-zag or waggle pattern. Aristotle described this behaviour in his Historia Animalium. It was thought to attract the attention of other bees.

In 1947, Karl von Frisch correlated the runs and turns of the dance to the distance and direction of the food source from the hive. The orientation of the dance correlates to the relative position of the sun to the food source, and the length of the waggle portion of the run is correlated to the distance from the hive. Also, the more vigorous the display is, the better the food. There is no evidence that this form of communication depends on individual learning.

Von Frisch performed a series of experiments to validate his theory. He was awarded the Nobel Prize in Physiology or Medicine in 1973 for his discoveries.

One of the most important lines of evidence on the origin and utility of the dance is that all of the known species and races of honey bees exhibit the behavior, but details of its execution vary among the different species. For example, in *Apis florea* and *Apis andreniformis* (the "dwarf honeybees") the dance is performed on the dorsal, horizontal portion of the nest, which is exposed. The runs and dances point directly toward the resource in these species. Each honey bee species has a characteristically different correlation of "waggling" to distance, as well. Such species-specific behavior suggests that this form of communication does not depend on learning but is rather determined genetically. It also suggests how the dance may have evolved.

Various experiments document that changes in the conditions under which the dance is performed lead to characteristic changes in recruitment to external resources, in a manner consistent with von Frisch's original conclusions. Researchers have also discovered other forms of honeybee dance communication, such as the tremble dance.

Odor plume

While the majority of researchers believe that bee dances give enough information to locate resources, proponents of the odor plume theory argue that the dance gives no actual guidance to a nectar source. They argue that bees instead are primarily recruited by odor. The purpose of the dance is simply to gain attention to the returning worker bee so she can share the odor of the nectar with other workers who will then follow the odor trail to the source.

The primary lines of evidence used by the odor plume advocates are

1. clinical experiments with odorless sugar sources which show that worker bees are unable to recruit to those sources and
2. logical difficulties of a small-scale dance (a few centimeters across) giving directions precise enough to hold the other bees on course during a flight that could be several kilometers long. Misreading by even a few degrees would lead the bee off course by hundreds of meters at the far end.

Neither of these points invalidate the dance theory, but simply suggest out that odor might be involved, which is indeed conceded by all proponents of dance theory. Critics of the odor plume theory counter that most natural nectar sources are relatively large -

orchards or entire fields. Precision may not be necessary or even desirable. They have also challenged the reproducibility of the odorless source experiment.

Significant to the argument are the elegant experiments of William F. Towne, of the Kutztown University in Pennsylvania, such as this pdf file, in which hives are moved to "mirror image" terrain settings, and thus fooled into both dancing about the wrong location for a nectar source, and successfully recruiting foragers to that wrong location, but only when the sun is obscured by clouds, forcing them to rely on terrain-based navigation rather than "solar ephemeris" based navigation. As the cloud cover breaks up, more and more bees correct their dances to indicate the actual location of nectar, and forager visits shift to the correct location.

The academic debate between these two theories is extremely polarized and often hostile. Adrian Wenner, a modern bee researcher, is the chief proponent of the odor plume theory (anti-dance). One supporter of Wenner's theories, Julian O'Dea, has proposed an evolutionary explanation for the "waggle dance" that does not involve communication from one bee to another, by claiming it may be a simple idiothetic movement that conveys no information . Conversely, experiments with robotic dummies were indeed able to induce some recruitment, which should not have been possible if the dance contains no information.

An article in the 18 September 2009 issue of New Scientist sets out evidence against the use by bees of the information in the dance.

The controversy persists, though it does so primarily due to an asymmetry between the two "camps"; those who study dance communication freely admit that odor is an essential component of the system, and even necessary at various stages of the recruitment process, including once a recruited forager reaches the vicinity of the resource (e.g.), while odor-plume advocates do not acknowledge that the dance contains any information whatsoever. Various experimental results demonstrate that the dance does convey information, but the use of this information may be context-dependent (e.g.), and this may explain why the results of earlier studies were inconsistent. In essence, both sides of the "controversy" agree that odor is used in recruitment to resources, but they differ strongly in opinion as to the information content of the dance.

Odor learning is usually tested by a method called the proboscis extension reflex.

Note: much of the research on the two competing hypotheses of communication has been restricted to Western honey bees. Other species of *Apis* use variants on the same theme, and other types of bees use other methods altogether.

Trophallaxis

The exchange of food, trophallaxis, is also used by means to communicate and includes information on the quality of and thus competition for a food source, temperature and water demand, and the condition of the queen (Sebeok, 1990).

Primer Pheromones

Research that was published in November 2004, by scientists under the leadership of Dr. Zachary Huang, Michigan State University indicates that so called primer pheromones play an important part in how a honey bee colony adjusts its distribution of labor most beneficially. In order to survive as a bee colony of sometimes 50,000 -100,000 individual bees, the communal structure has to be adaptable to seasonal changes and the availability of food. The division of labor has to adjust itself to the resources available from foraging. While the division of labor in a bee colony is quite complex, the work can be roughly seen as work inside the hive and outside the hive. Younger bees play a role inside the hive while older bees play a role outside the hive mostly as foragers. Huang's team found that forager bees gather and carry a chemical called ethyl oleate in the stomach. The forager bees feed this primer pheromone to the worker bees, and the chemical keeps them in a nurse bee state. The pheromone prevents the nurse bees from maturing too early to become forager bees. As forager bees die off, less of the ethyl oleate is available and nurse bees more quickly mature to become foragers. It appears that this control system is an example of decentralized decision making in the bee colony.

Cognition

Experiments by James Gould suggest that honey bees may have a cognitive map for information they have learned, and utilize it when communicating.

In one test reported in a 1983 issue of *Science News*, he moved a supply of sugar water 25% further away from a hive each day. The bees communicated to each other as usual on its location. Then he placed the sugar water on a boat anchored in the middle of a small lake. When scouts returned to the hive to communicate their find, other bees refused to go with them, not expecting to find food in the middle of a lake, even though they frequently flew over the lake to reach pollen sources on the opposite shore.

In another test related in the August 1986 issue of *Discover* ("A Honey of a Question: Are Bees Intelligent?"), Gould lured some bees to a dish of artificial nectar, then gradually moved it farther from the hive after they became accustomed to it. He marked the addicted bees, placed them in a darkened jar, and relocated them to a spot where the hive was still visible, but not the dish. When released one by one, the bees would appear disoriented for a few seconds, then fly directly for the covert dish. 73 of 75 bees reached it in about 28 seconds. They apparently accomplished this feat by devising a new flight path based on a cognitive map of visible landmarks.