The psychologists' tree of life

Psychologists in research and practice work with a surprising number of different species – animals, plants, and even beyond to the world of parasites and viruses. Our journalist Ella Rhodes spoke to some of them, from across the world, about their encounters and what other life might teach us about our own.

A magic well

Social organisation, learning and memory in bees

Professor Martin Giurfa *is a Researcher at the Research Centre on Animal Cognition, Paul Sabatier University, Toulouse*

My memories of bees go back to my childhood, when I would spend hours watching them foraging on the flowers of my garden. I always was what you would describe as an animal lover. I had a menagerie of animals, much to the dismay of my highly tolerant mother. I was particularly attracted by insects, with their fascinating forms, colours and adaptations to all possible lifestyles. I remember admiring the hard work of bees, collecting food not for them but for the colony, and asking myself: 'How does this work?' My questions then snowballed: 'To what extent are humans different?' and 'What can we learn about ourselves by studying animals?' Bees combine two attractive features for someone willing to understand the mechanisms of learning and memory and the biological bases of social behaviour: their sophisticated social organisation and their remarkable learning and memory capabilities.

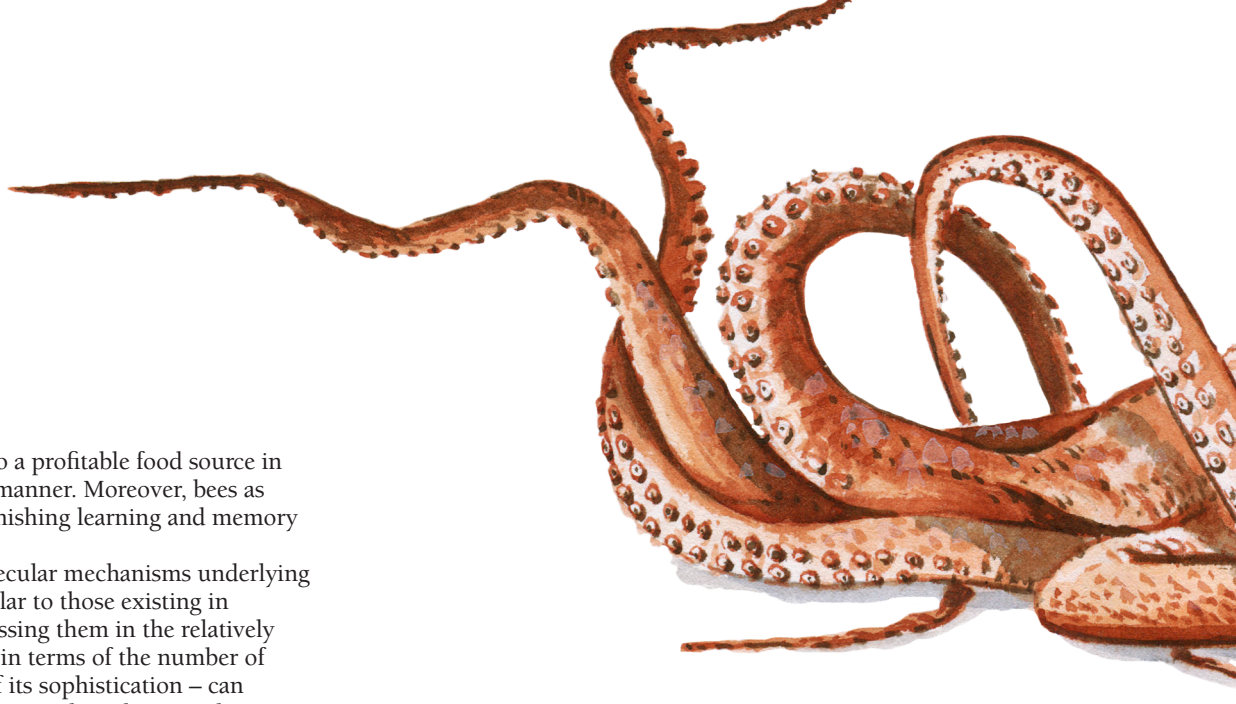
Bees are one of the best examples known of animal sociality. Their society relies on division of labour and on elaborate communication systems, such as a rich pheromone repertoire and bee dances, which report

distance and direction to a profitable food source in a unique and exquisite manner. Moreover, bees as individuals exhibit astonishing learning and memory capacities.

The neural and molecular mechanisms underlying these capacities are similar to those existing in vertebrates, so that accessing them in the relatively 'simple' brain of a bee – in terms of the number of neurons, not in terms of its sophistication – can provide valuable information about how our brain learns and memorises. The fact that in the last decade, capacities such as concept formation, categorisation and a basic numeric sense have been discovered in bees, opens new perspectives to uncover the neural underpinnings of these abilities in an accessible brain. In that sense, as Nobel Prize winner Karl von Frisch said once, *'the bee's life is like a magic well: the more you draw from it, the more it fills with water'*.

I am interested in learning and memory, which I analyse at multiple levels, from behaviour to their cellular and molecular bases. Studying a brain endowed with these capacities and that allows the use of a series of invasive techniques specially adapted and conceived for its miniature size and characteristics in the laboratory (brain imaging, electrophysiology, RNAi-blockade of receptors, etc.) constitutes a valid way to gain more knowledge on the mechanisms of these capacities. In many cases, these mechanisms rely on 'universal' key-molecules and /or circuit organisation, so it is a fundamental way to understand the underpinnings of learning and memory, at the core of both psychological research and theory.

The interesting question concerning bees refers to their higher-order learning capacities, which for many years were considered a prerogative of some vertebrates (e.g. conceptual learning). This finding raises the question of the uniqueness of vertebrates and in particular of humans: where does this uniqueness lie (if it lies somewhere) given that at the end highly elaborate cognitive processing can be found in the miniature brain of an insect? We can definitely provide answers to this question and find capacities, which are not at the reach of an insect brain, but at least the bee case helps questioning some preconceived ideas about the place of humans in nature. Moreover, the discovery of these capacities raises also the question of negative results in the animal cognition literature. Are all animals necessarily limited in their capacities, or is it rather that experimenters have not found yet the clever experiments to uncover what animals can do?



Curiosity and the cephalopods

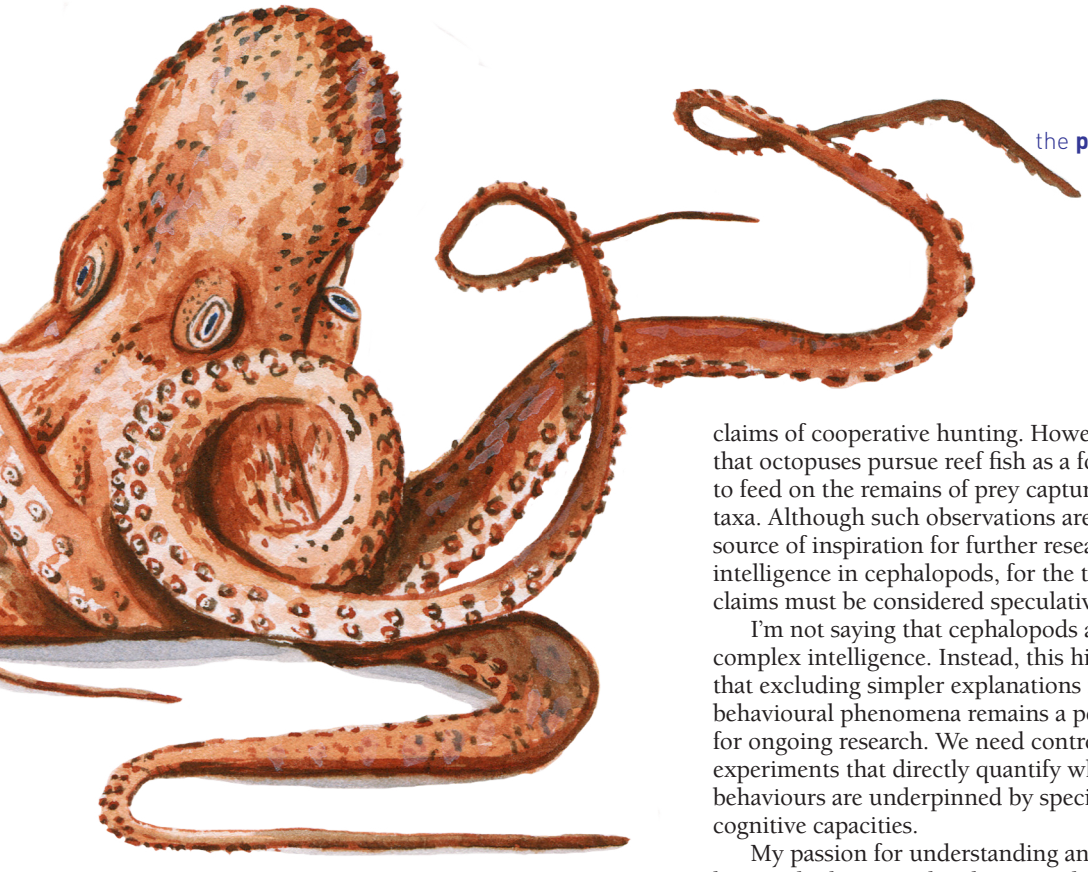
An encounter with the strange and compelling octopus

Dr Alexandra Schnell
is a researcher in animal communication, cognition and evolution and works between the Marine Biological Laboratory in Massachusetts, USA and the University of Cambridge

The alien-like creature was tucked away in an underwater cavern, staring at me inquisitively through a large eye with a horizontal pupil. As I breathed out, bubbles were released from my regulator. The creature's gaze followed the bubble trail before its soft-suckered arm extended out to touch them. Engrossed, I reached out with my gloved hand; the creature turned its gaze back to me and then proceeded to wrap the tip of its flexible arm around my wrist. We stared at each other, our limbs entwined, both seemingly enthralled in the oddity of the exchange. That was the moment I became captivated by these enigmatic creatures.

Cephalopods – which include octopus, cuttlefish, and squid – are soft-bodied marine molluscs, with eight arms, blue blood, a concealed parrot-like beak and three hearts. Despite their peculiar appearance, cephalopods are well known for their large-brains and remarkable behaviour. They have been observed to unlock aquarium tanks at specific times of day and to collect shells and other objects to shield their soft bodies from prospective predators.

Their behaviours have led to claims of complex intelligence such as planning for the future and remembering the past. Both capacities were previously thought to be unique to mammals and corvids (a group of intelligent birds) and to have evolved in response to pressures experienced in their physical and social environments. Recently, episodic-like memory has been demonstrated in cuttlefish. This cognitively demanding capacity involves the recollection of personally experienced memories based on what happened, where it happened and when. Cuttlefish



were shown to selectively revisit locations (*where*) depending on food preferences (*what*) and prey availability, as well as the time that elapsed since their last visit (*when*).

The prospect of complex intelligence having emerged in cephalopods has challenged the traditional understanding of how intelligence evolved, primarily because cephalopods have diverged radically from the vertebrate lineage. Moreover, most cephalopods do not show sophisticated social recognition abilities, suggesting that they, unlike most vertebrates, have not faced strong social pressures. However, apart from the episodic-like memory study in cuttlefish, our current understanding of cephalopod intelligence is largely based on observations, meaning many claims remain unsupported by quantitative data.

Other explanations

Currently, observed behaviours labelled as complex cognition can be explained as less complex abilities that involve simple conditioning (i.e. learning that a stimulus is associated with a reward) or hardwired predispositions (i.e. fixed action patterns that are stimulated by an environmental cue). For example, octopuses have been observed carrying coconut shells across sandy ocean floors, leading to claims of anticipating future needs for shelter. Yet, it is possible that this behaviour may be driven by current needs to protect themselves from predators without any appreciation of needing shelter in the future. In another example, octopuses were observed swimming in close proximity to foraging reef fish, leading to claims of cooperative hunting. However, it is plausible that octopuses pursue reef fish as a foraging strategy to feed on the remains of prey captured by other taxa. Although such observations are an appropriate source of inspiration for further research into complex intelligence in cephalopods, for the time being these claims must be considered speculative.

I'm not saying that cephalopods are incapable of complex intelligence. Instead, this highlights the fact that excluding simpler explanations for the observed behavioural phenomena remains a persistent challenge for ongoing research. We need controlled laboratory experiments that directly quantify whether such behaviours are underpinned by specific complex cognitive capacities.

My passion for understanding animal minds has resulted in countless hours in the laboratory, and several ongoing efforts to empirically quantify the remarkable behaviours of cephalopods. Most recently, my team tested whether cuttlefish exhibit biases when processing visual information during different ecological activities. We found that cuttlefish predominately use their left eye and associated brain structures to scan for predators, and predominately use their right eye and associated brain structures to search for prey. This manner of processing cognitive information is analogous to the way most vertebrates process cognitive information. These findings highlight that even though cephalopods are separated from vertebrates by approximately 550 million years of evolution, both animal groups use different parts of their brain to process cognitive information. Yet the central question still remains – how intelligent are cephalopods compared to cognitively advanced vertebrates?

In my future research, I hope to address this question by directly quantifying complex intelligence in a range of different cephalopod species. The key is to test whether cephalopods are capable of complex capacities that parallel other cognitively advanced animals. I have developed a series of innovative behavioural experiments that will test the capacity for cephalopod cognition in a comparative context. This data will deliver key insights into whether comparable intelligence can evolve in the absence of strong social pressures. Such findings will provide a unique perspective for understanding the selective pressures that have shaped animal intelligence, and may even have consequences for understanding the origins of human intelligence. Until then, the true cognitive capacities of these large-brained molluscs will remain a mystery.

‘Yours, in defiance and admiration’

A letter to HIV

Dear HIV,

Kavita Vedhara *is Professor of Health Psychology at the University of Nottingham*

Wow! – has it really been almost 30 years since we first met? I was obviously aware of you before then. But I think our first meaningful introduction was in biological psychology.

Once in a while we are confronted with information that makes us question who we are and what we know to be true: cognitive dissonance if you will. And so it was with you. There, in my second-year lecture, I realised that you, the most ignominious of viruses, had found a way to destroy the very system that protects us from all other diseases.

At first, your story looked like one of biological determinism. Nature trumps nurture. There appeared to be nothing we could do to combat you. But actually, the power of the mind and human behaviour was to be the real story. From the very beginning there was evidence that the speed with which you progressed could be shaped by how a person reacted to you (in the way they coped, felt, behaved and their social resources). You also unleashed the gargantuan efforts of a generation of scientists who developed treatments that turned you from a fatal disease to a chronic condition.

So did nurture trump nature? Perhaps not. There are fault-lines in our ability to contain you. Some of these are behavioural: like the fact that treatments are only effective if people are able to adhere to their medication regimens. Others are biological: like your ability to mutate. You are clearly a force to be reckoned with; and our rivalry, and with it the sibling rivalry between nature and nature, is set to continue.....

Yours, in defiance and admiration,

Kavita

Wayfinding ants

Towards a different view of intelligence

Dr Antoine Wystrach *works at the Research Centre on Animal Cognition, Paul Sabatier University, Toulouse*

There is no doubt that insects are much smarter than we used to think. In the last few years, research has shown that some insects can count up to four, solve remarkably complex experimental tasks, form mental abstract concepts, use symbolic language, actively teach their knowledge to others, achieve metacognition to evaluate their uncertainty, and can learn things completely off their natural repertoire, such as bumblebees playing golf. The boundary between human and insect cognition is getting blurry, and given the rate of new such publications, there will probably be many more surprises to come before we reach the limit of their intelligence.

What is really surprising is that an insect brain is usually less than 1mm^3 – we could fit their entire brain within a single voxel (3D pixel) of an fMRI image. How can so much intelligence be packed into such a small piece of matter? Why does our own human brain needs to be so big? Questions such as these are pretty exciting, and got me into studying insects’ behaviour.

I started with carefully designed experiments with ants in the lab with a hope of discovering new and unexpected cognitive abilities. The paradigms I was using were mostly inspired by experimental psychology studies with vertebrates such as humans, other primates or rodents. The ants were usually doing well, matching and sometimes even outperforming the scores of vertebrates. However, these discoveries were not so unexpected after all, as each experiment was designed to reveal a given cognitive ability that I had chosen in the first place. At one point I realised that I was not looking for insect intelligence, but for human intelligence in insects.

This is when I decided to go to the field and see what these ants were really doing in their natural environment. I started in the Amazonian rainforest, and it took less than a day to realise that the questions I had been asking in the lab were off the mark. It was now obvious that these ants had evolved to cope with a specific problem – finding their way alone in the rainforest to bring food to their nest. And they were outstanding at it! Each individual ant spontaneously ventures from its nest alone, and can remember visually a 30m long route through the chaos of the forest’s floor… even if you displaced them, on the way back they had no problem returning to the tiny entrance of their nest, a 3mm hole somewhere in the midst of the clutter. This

is an extremely complex spatial learning task, and what's more, a single trial is enough for them to remember a route using vision! Put to human scale, this would be equivalent to learning a 3km long route in one go… in this kind of forest, 30m is enough to get most of us completely lost.

From then on, my scientific questions are drawn from such naturalistic observations, rather than purely human introspection. Instead of using a standardised paradigm to compare across species, I try to design experiments that are tuned to the animals' specific natural tendencies. For instance, if you want to study spatial memory, use route following with ants, food caching with crows, and don't forget olfaction with rodents. This approach has been paying off. First of all, the animals are much more cooperative and motivated, which usually results in clear-cut experimental outcomes. Also, ensuing discoveries can be truly unexpected, even counterintuitive, and thus very insightful. For instance, after quantifying how poorly sighted ants were, we discovered that parsing the world with such a low-resolution vision is actually better for navigating in natural environments. This may well explain why our human peripheral vision has a similarly low resolution, and why we, counterintuitively, do not need to recognise objects to follow well-known routes.

Insects are also good models for neurobiology. These are particularly exciting times, as modern neurobiological tools enable us to observe and manipulate insects' brains at the single-cell level. This allowed us for instance to understand how different neural pathways could compute and store the visual information necessary to recapitulate such a 30m-long route in a complex environment. Actually, by modelling an extremely simplified version of an ant brain, we showed that 10,000 neurons turn out to be enough to achieve this task. An insect brain contains up to 1 million neurons, each of which can make up to 100,000 connections with other neurons. There is still a long way before we fully understand insect intelligence, but the future is bright. Interestingly, the connectivity of some insects' brain areas turns out to be surprisingly similar to vertebrates' brain areas, and thus can provide very useful insights to help us understand the building blocks of our own intelligence.

My studies with insects in the field brought me some fresh air, a regular stream of novel questions, and a different view of intelligence – it is something that cannot be isolated in a lab, as it requires the many invisible links that tie an animal to its natural environment.

A matter of pride

Why are lions and the groups they live in a good focus of research for a social psychologist?

Dr Jackie Abell
is a Reader in Psychology at Coventry University

Hands up, who hasn't been told to go to a conference to 'network' at some point in their academic career. Getting yourself connected into influential social networks can pay dividends both professionally and personally.

In 2013 I took a leap, changed direction, and forged a research career as a social psychologist in lion conservation. Excited by an opportunity I'd been given in Zambia and Zimbabwe to do exactly that, I packed my bags. However, I was warned that there were obstacles to my acceptance amongst fellow lion conservationists. I had the wrong PhD. Mine was in psychology. Worse, it was in social psychology! I was urged to enrol for another PhD in wildlife conservation or something 'biological' to ingratiate myself into the influential network of movers and shakers within the lion conservation world. My social science background was irrelevant. How rude. How ironic.

Thankfully, wildlife conservation now focuses on working with local communities to develop initiatives that ensure those who live with the risks of protecting a species also receive benefits from doing so. Having unfenced lions living as your neighbour is not on most people's wish-lists. We're developing educational and social programmes that enhance local communities' access to employment and sustainable income revenues, reducing the need to depend on natural resources to forge a living. These include conservation education, where feasible solutions to mitigating conflict with lions are developed and implemented, without loss to people and an increasingly diminishing lion population.

Here the application of psychology seems obvious. But what about the lions themselves? Well, lions live in groups. Social psychologists know a thing or two about groups.

Social network analysis (SNA) has a long history within the social sciences. SNA defines a plethora of methods that share a basic premise: social connectedness with others matters. The more networked in you are, communicating with others, the better your access and influence over information. You can see why the social sciences have embraced SNA to explore relationships of communication and power across a variety of domains.

Within the field of animal behaviour, researchers such as Jens Krause have realised the utility of SNA to examine social cohesion and hierarchies amongst non-human animals. If we think of groups as powerful social networks, and assume the players within them are not equal, this might hold the key to understanding how some animal societies function – which might prove crucial for their effective conservation.

Lion prides describe adult females and their cubs. Males can take over a pride and hold tenure for two to three years (sometimes longer), but will eventually be overthrown by fitter males seeking the opportunity to breed and enjoy the benefits of group living

including cooperation in nurturing young, hunting and territorial defence. A lion's chance of success in the wild is improved by pride living. So, to protect lions, we should focus on pride structure and function to maximise their chances.

Considering conservation

Prides have tended to be taken for granted in the research literature. They exist. There has been little focus on *how* they exist, how they are sustained, and the roles of the lions within them. Andrew Sih and colleagues describe 'keystone' individuals in SNA; the 'social glue' of a group because of their tight connections with all others within the networks. In its simplest form: Individuals A and B might not be friends with each other, but they are connected through a relationship they both have with C. That makes C key to holding the group together.

I've been lucky enough to spend time with lion prides and study their behaviour to examine their structure and function. Each pride has an adult female 'keystone' member who 'glues' the pride together. She holds the most social connections, is the best networked individual, and the most socially influential. She dictates the pride's movements. Identifying and protecting these keystones is crucial if we are to maintain the integrity of wild prides. Removal of the keystone can lead to the break-up of the group if no other lion steps up to the plate. If we consider that key threats to lions include persecution and disease, keystones can be prime targets. Efforts to restore lions include the translocation of lions across areas, and the reintroduction of lions to the wild. These efforts must identify and understand the structure of prides to ensure crucial social networks are protected in that process.

As psychologists know, social networks matter. Including psychology into wildlife conservation networks might prove key to protecting this diverse field.

Fascinating fruit flies

Can such a tiny brain be a good model for study of humans?

Professor Reuven Dukas *leads a lab within the Animal Behaviour Group in the Department of Psychology, Neuroscience and Behaviour at McMaster University in Canada*

I have studied a wide variety of animals, some of them I certainly do love. These include blue jays, honey bees, bumble bees and wasps. I have to confess that fruit flies do not generate, at least in me, the same emotions. I don't know why, but research on emotion using fruit flies as a model system will likely help us understand why! Can one do research on emotion in fruit flies? Yes, indeed one can fruitfully study almost anything in fruit flies.

I certainly altered my attitude from indifference to admiration once I started to work with them. These small animals have only about 100,000 neurons in their tiny brains compared to our brains, which contain approximately 100 billion neurons. Yet fruit flies have sophisticated sensory systems, highly complex behaviours and fair learning and memory abilities. And they can even readily fly and land safely – a remarkably challenging activity.

Cerebrally, I am fascinated by fruit flies as well as by the numerous ingenious scientists who have studied them for over a century and developed a vast collection of research tools for examining all aspects of life. One piece of evidence for the remarkably successful use of fruit flies as a model system for biological research is the fact that they have helped earn their tireless researchers six Nobel Prizes in Physiology or Medicine.

A fact that surprises even me is that 87 per cent of human mental impairment genes have fruit fly equivalents! This makes fruit flies a powerful model system for psychological research and its biological foundations. This is not a remotely relevant ivory-tower statement. Fruit flies have provided numerous insights into a variety of human basic psychological features and impairments including autism, ADHD and Alzheimer's disease as well as other

neurodegenerative disorders. While it takes time and money for such basic research to translate into human applications, there are many promising lines of such applied research. One example is basic research on fruit fly memory, that has led to the creation of a specialised drug company devoted to the discovery and development of innovative drugs for memory disorders.

I am not ready to suggest what fruit flies can tell us about being human, but expect to have a thorough answer in about ten years. We have been looking into perseverance, which we define as persistence in a course of action despite difficulty or with little or no indication of success. Thanks to some unknown cultural bias, we tend to overvalue intelligence, which has been extensively studied, and to undervalue perseverance. For example, saying that a colleague of mine is a hard worker may be perceived as an insult, implicitly implying he is not very smart. Because of this bias, we know too little about the biological foundations of perseverance. So now we are testing for genetic variation in perseverance and how it is related to individual performance. The next phase of this research will involve a search for the genes that mediate perseverance.

If you are still sceptical, I strongly recommend the highly readable book *Time, Love, Memory* by Pulitzer Prize winner Jonathan Weiner. In spite of the title, it is about fruit fly researchers and their fascinating work on key psychological features we all care about.

Flipper isn't what you think

Dolphins can be quite different from the TV depiction

Professor Janet Mann
is a researcher in the Department of Biology and Department of Psychology at Georgetown University in Washington, DC

I have been fortunate to observe dolphins close up for over three decades. It began with a trip in graduate school to a remote part of Australia and will continue until I can no longer manage it. We know them as individuals and have followed them from birth to death. Some of the dolphins are well into their 40s (no menopause), but their maximum lifespan is not known. Shark Bay, Australia, is an ideal place to study dolphins because the water is shallow and clear and protected from strong winds. So we can see what the dolphins are doing and have devised a number of techniques to study them. My background was originally in primatology, and from my first field season, I could see the potential of studying a mind in the waters.

Let us get a few things out of the way first. Flipper, the star of the American TV show which aired from 1964 to 1967, was played by five different female bottlenose dolphins. The image of a male dolphin protecting the marine preserve and saving humans from their foibles persists today. The US Navy has trained dolphins to protect harbours and ships and to retrieve equipment. And, there is the occasional intriguing story about dolphins saving humans. Female dolphins, but not males, are known to push a struggling calf or human to the surface, and I have witnessed females jointly mobbing immense sharks.

The sound that Flipper supposedly made was modified from a kookaburra – an Australian bird, a bird also used for *Tarzan* soundtracks. And the mouth agape one sees so often amongst captive dolphins, including Flipper, is a begging gesture. It means: 'give me a fish!' Dolphins do not open their mouths to make sounds. Dolphin sounds are produced in nasal sacs and come out through the melon, the fatty organ in the head. No moving mouth parts required. Perhaps this is why I never liked the show.

Social complexity

While female dolphins are fairly gentle and maybe kind, it turns out that male dolphins are not. In fact, they can be quite aggressive, and in Shark Bay they form long-term alliances or small gangs, ranging in size from two to 14 males. Alliances cooperate to challenge other male alliances and they even cooperate with other alliances to defeat a third. All of this is with the goal of achieving mating access to individual females. That is, males fight to gain access to a fertile female, but they also use their power to coerce the female into staying with them. That does not mean that males can force a female to mate. We commonly see females twist and turn belly-up so that the males cannot easily mate with them. While the mating antics might not seem familiar to humans, allied sexual coercion has been

Getty Images

"These are the hallmarks of a complex mammal with a far more interesting social life than anything *Flipper* dared to show"

documented in three species – humans, chimpanzees and bottlenose dolphins – even though their mating systems are strikingly different. While sexual conflict is widespread in the animal kingdom, alliances are not, and this elaborate and long-term cooperative relationship is considered one hallmark of social intelligence.

Relative to males, it is females who are the most skilled and diverse hunters. They use a variety of tactics, from tool-use with sponges, to strand-foraging where the female hydroplanes in shallow water and launches her body onto the shore to trap prey. Sponge-tool-use in Shark Bay is famous; about 5 per cent of the population uses basket marine sponges they have dislodged from the seafloor, wear them on their beak and use them to find bottom-dwelling camouflaged prey. Among the many smart things dolphins do, one intelligent aspect of this is that the fish they exploit do not have swim bladders and are thus 'inaudible' via echolocation. The sponge allows the dolphins to protect their beak while searching the seafloor for virtually invisible and inaudible prey. This and many other tactics are female-biased and learned almost exclusively from the mother. We have also shown that spongers – as we call them – prefer to associate with one another, while controlling for geo-spatial overlap and genetic relatedness, even though sponging is a solitary enterprise. This preference based on tool-use suggests a sponge-culture as the behaviour is socially learned and differentiates between groups.

Bottlenose dolphins have challenged our views of their intelligence, but not in the ways the show *Flipper* might suggest. Their social complexity is impressive – and to explain this, and how it compares with humans, we must consider what social complexity is. Most characterise socially complex mammalian societies as having well-differentiated, long-term bonds, large numbers of associates to keep track of, and fission-fusion dynamics. The latter term refers to spatio-temporal dynamics of association. Humans have high fission-fusion dynamics in that the entire community is rarely or never in one place. Groups change membership constantly, although there are regular companions (in humans: spouse-partner-kin-friends-co-workers). In dolphins the average group size is four to six dolphins, but many spend half their time alone and groups can be larger than 50. Group composition changes nearly six times per hour on average. Among the hundreds of dolphins we study, each individual has a network of 100+ associates that they regularly interact with. Captive studies have shown individual-recognition that lasts at least 20 years, even without contact, and this resonates with our field observations. Dolphins have well-differentiated relationships with many individuals, but they also seem to understand the nature of the bonds between others. Male and female dolphins have close, long-term same-sex bonds, lasting decades, but the nature of these bonds differs. Understanding who is with whom and why is compelling area of research.

The parallels between humans and bottlenose dolphins are striking despite a common ancestry that is ~90 million years distant. Individual recognition, long-term bonds, multi-level alliances, prolonged dependency and extended learning, cultural transmission and intricate social networks based on elaborate patterns of fission and fusion. These are the hallmarks of a complex mammal with a far more interesting social life than anything *Flipper* dared to show.

Melissa and me

The interesting and unusual effects of lemon balm on mood and cognition

I first encountered Melissa during a series of studies evaluating the potential mood and cognitive-enhancing effects of botanical extracts with my then PhD student David Kennedy. This included a series of studies that followed a fairly standard, though pretty intense, methodology aimed at capturing any acute mood or cognitive effects of botanicals. In these studies, participants visited the lab on five test days where they received a placebo or one of several doses of a plant extract. Aspects of participants' mood and cognitive function were tested at baseline then at five time-points over the course of the day. So these studies were straightforward but required a huge amount of time to conduct and analyse. In many cases this was the first time the behavioural effects of the herbs had been scrutinised to this extent – despite claims in adverts and websites. Thus they paved the way for future studies in the field. One striking aspect was that in some (but not all) cases, the effects were in keeping with their traditional use. One such example was *Melissa officinalis*, more commonly known as lemon balm.

Professor Andrew Scholey
is Director of the Centre for Human Psychopharmacology at Swinburne University, Melbourne
Twitter: @scholey

Melissa has a long history as a medicinal plant. Various historical textbooks have referred to its mood-altering and pro-cognitive properties. For example, in the 17th century in his *Complete Herbal* Nicholas Culpeper wrote that lemon balm *'cheers the heart, refreshes the mind, takes away griefs, sorrow, and care, instead of which it produces joy and mirth'*. We didn't have a scale that measured the mood dimension ranging from 'grief-sorry-care' to 'joy-mirth'! But we did have the Bond–Lader visual analogue mood scales, which have been widely used in psychopharmacology for decades. These produce ratings of calmness, contentment and alertness. Our studies showed that *Melissa* fairly consistently improved self-rated 'calmness' as well as producing certain changes to cognitive performance.

Although the initial studies had been fascinating, we were both interested in moving beyond plugging different herbs into the same system. By lucky coincidence Elaine Perry was working in Newcastle at the MRC Neurochemistry Unit at the same time. Elaine also had a longstanding interest in medicinal herbs for the brain, and owned a physic garden in Northumberland. She was something of an inspiration to me and the group. She also had access to human brain tissue and introduced us to George Wake, who performed binding assays from various extracts of *Melissa*, in particular looking at their capacity to bind receptors for the neurotransmitter acetylcholine, which is depleted in Alzheimer's disease.

David then tested the extracts with the strongest and weakest binding using our model system for assessing mood and cognition. As with previous studies, both extracts improved self-rated calmness. However, only the extract that bound most strongly to the two cholinergic receptors also enhanced

memory. This suggested that the cholinergic binding properties of the herb are responsible for *Melissa*'s memory enhancement, whereas some other physiological property is responsible for its calming effects.

This mood improvement occurred when volunteers simply visited the lab and did very little other than standardised cognitive tests. I was also interested in whether *Melissa* would help to buffer against stress. I'd met Mark Wetherell a few times at the excellent BPS Psychobiology Section annual conference. He had developed an elegant laboratory stressor – the Purple multi-tasking framework (MTF), which involves simultaneously co-performing four tasks (e.g. mental arithmetic, Stroop, working memory and psychomotor tracking). Performing the MTF for 20 minutes reliably induces a mild negative mood state. I designed a study with a dissertation student, Wendy Little, where volunteers underwent the MTF after taking 300 mg, 600 mg of *Melissa* or a placebo capsule. Following placebo the MTF produced the typical mood profile of reducing self-rated 'calmness'. This effect was not seen in those who had taken a 300 mg dose of *Melissa* extract suggesting that this does was capable of 'buffering' the stressful effects of completing the MTF.

Many of the plant extracts that myself and colleagues have worked with over the years taste disgusting. One advantage of *Melissa* is that it is quite palatable, meaning that it can be added to foods at doses that may produce benefits to mood and cognition. We verified this in a couple of studies into the effects of three doses of *Melissa* delivered in a drink and in a yoghurt. When delivered in a drink, one dose of *Melissa* reduced the anxiety associated with performing the MTF at one and three hours (although a different dose increased it). The beneficial dose also improved working memory and reduced cortisol responses to the MTF. There were also benefits to different measures when *Melissa* was presented in a yoghurt, but in this case there were also increases in fatigue.

Further work from Elaine Perry demonstrated that lemon balm applied topically in an essential oil reduced agitation in Alzheimer's disease patients. We know from work from Mark Moss, another of my former PhD students, that some of the actives in such oils are detectable in plasma following exposure, with plasma levels correlating with cognitive performance.

There's a long way to go, but these disparate lines of evidence suggest that some part of *Melissa* may be used to improve mood and cognition during ageing and cognitive decline. This is something I think about whenever I see and smell the small, nettle-like leaves of this plant which grows like a weed in many places.

Thinking, smelling and saving elephants

Comparative cognition and conservation with a beloved pachyderm

The question animal cognition researchers are often asked is, 'When did you first realise you were going to dedicate your life to [insert species here]?' It's true that many of us do feel a deep passion for the animals we study, but what drives most scientists are the empirical questions that a certain study species lets us ask about behaviour, cognition and the evolution of both.

Dr Joshua Plotnik *is an assistant professor of psychology in the animal behaviour and conservation program at Hunter College, City University of New York*

I wish I could say that I first 'fell in love with elephants' when I visited the Bronx Zoo in New York as a 12-year-old middle school student; back then, I had wanted to be a veterinarian. But instead, it happened sometime in July 2005, when I was a graduate student at Emory University in Atlanta. While sitting on the elephant barn roof on a blazing hot day at that same zoo during a summer in NYC, Diana Reiss (now a colleague of mine at Hunter College but then a researcher at the Wildlife Conservation Society) and I sat, holding our collective breaths, watching as Maxine, Patty and Happy (all Asian elephants) stared at themselves in an oversized, acrylic mirror. As a graduate student in the lab of primatologist Frans de Waal, I was excited about research questions focused on understanding the evolution of human behaviour and intelligence that used our closest living relatives, the great apes, as living models. But when Professor de Waal offered me a chance to study the mind of elephants (by looking at their ability to recognise themselves in a mirror), I jumped at the chance.

While watching the elephants from that rooftop, we observed them stick their trunks inside their mouths and pull on their ears, and eventually, in a hallmark test of self-awareness, one of them, Happy, reached up and touched a white X we had painted on her forehead. I realised at the time that we had stumbled onto something really exciting. Elephants, as demonstrated by the mirror test, were self-aware.

But I also saw that a relatively new area of research, the study of convergent cognitive evolution (CCE), might have a place for elephants as well. CCE suggests that although the similar cognitive abilities we see between the great apes (humans, chimpanzees, bonobos, gorillas and orangutans), are likely due to our shared common ancestry, similarities we see between the same species and dolphins, corvids (the bird family that includes crows and ravens), and elephants are likely due to something else entirely. The study of CCE is exciting because it suggests that intelligence may evolve independently in evolutionarily distant species because of similar pressures these animals face in their physical and social worlds. Thus, one reason elephants and humans may, for example, share the capacity for close, cooperative bonds with family members is that working together with others (and being able to think through the problems you face with them) may have helped these quite different species survive in difficult environments.

For more than a decade I have been studying the cognition of elephants in Thailand. Although years of observational research on elephants in Africa and Asia has shown us that elephants live complex lives in difficult environments, only recently have scientists begun to conduct controlled experiments on elephant cognition in 'field laboratories' (think plastic buckets, local artisan-built apparatuses and portioned food rewards rather than multi-million dollar lab spaces on campus). With students and a dedicated research team, I've investigated cooperation (elephants work together to pull opposite ends of a rope attached to a table in order to gain access to food), consolation (they reassure friends and family in distress by gently touching them and showing similar emotions), human/elephant social dynamics (elephants respond to some but not all human-provided social cues), and, most recently, the use of olfaction in complex cognition (the elephants' sense of smell seems to be crucially important to them when finding food and solving problems).

> "To best understand how elephants think, we need to try to design cognitive experiments that play to their sensory strengths... what does it mean to know the world through one's trunk?"

One crucial problem the field of comparative cognition faces, in my opinion, is how best to compare the evolution of intelligence in animals that may exhibit similarities in capacity but not in perspective. In other words, animals that primarily 'see' their world through their noses or their ears should not necessarily be expected to do well on problem-solving tasks designed by scientists with visual animals in mind. This means that in order to best understand how

The curious, cooperative kea

Intelligence in this alpine parrot

Dr Alexander Harwood Taylor
is a Researcher and Senior Lecturer at the University of Auckland in New Zealand

As an undergraduate I saw Betty the New Caledonian crow astound the Biology Department at the University of Oxford by bending a wire into a hook to pull a bucket out of a tube. This sparked my fascination with bird intelligence. After over 10 years studying the intelligence of New Caledonian crows I've recently also started focusing on kea, the only species of alpine parrot in the world, which is native to New Zealand. It's hard to spend five minutes with a kea without being curious about what goes on between their ears – their levels of sociality and play are quite astounding, as is their love of new objects.

We work with a population of kea at Willowbank Nature Reserve near Christchurch in New Zealand, providing physical and mental enrichment for this group, while also gaining insight into how they think. Going into the enclosure the kea act so differently from the other bird species I have worked with. They are so, so curious and playful towards the objects around them, including you. They are keen to nibble your shoelaces if you let them and will have whisked away your

elephants, dolphins and crows think, for instance, we need to try to design cognitive experiments that play to their sensory strengths. For elephants, this isn't easy; they have a large olfactory bulb in their brain and a multitasking, olfactory and tactile trunk that contains tens of thousands of muscles. How are we as humans to guess what it means to know one's world through one's trunk?! We have to enter their physical and social worlds, to look at how they problem solve using their senses of smell and hearing. We hope that this will open up our understanding of how elephants make decisions in the wild, and how their cognitive complexity compares to our own. We are looking at capacities like quantity understanding, distance judgement, and problem-solving, and can't wait to report what we find.

However, as a scientist studying an endangered species, I also feel that it is critically important for my research to have some impact on elephant conservation. In addition to running education programs for children in the US and Thailand where my colleagues and I bring elephants into classrooms via Skype to encourage critical thinking in middle school-aged students (www.thinkelephants.org), I am also conducting research aimed at investigating how elephant behaviour and cognition can inform human/elephant conflict. In Southeast Asia, the main conservation issues facing elephants involve habitat loss and human encroachment on national park lands. This means that humans and elephants are competing for the same space and resources, which inevitably leads to conflict between the species. Although conflict mitigation is of tremendous interest to conservation organisations, strategies such as fencing, chemical deterrents, and translocating elephants often have limited rather than long-term efficacy. Our research will aim to identify how elephants decide to raid farmers' crops, what makes a crop-raiding elephant take risks, and how the study of these choices can help prevent conflict before it begins. It's an ambitious endeavour, I'll admit, but super exciting too. The application of animal cognition to endangered species conservation is a new and quickly evolving field, and I am thrilled to try to be a part of it moving forward.

pen before you know it. As soon as they get tired of that, they often go straight back to playing with each other or other objects in their habitat. There is a stream running through the aviary with some logs in it and, apropos of nothing, they will often team up to rock the logs from side to side, causing the water to splash. In general they give the impression that they're having a fantastic time!

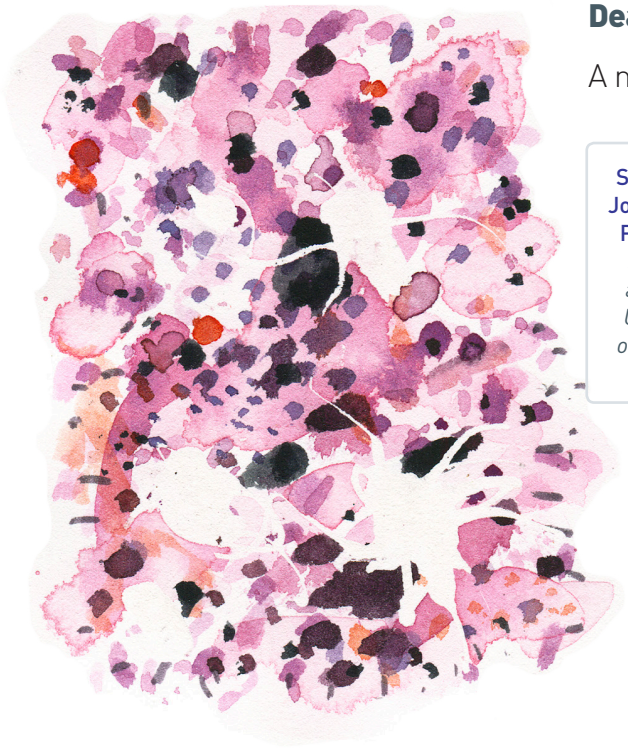
Behaviours like the log splashing inspired my former PhD student Megan Heaney to run a series of experiments focused on the social cognition of the kea. We were particularly interested in if the kea understood anything about cooperation. Did they realise they needed two kea to move heavier logs? Did they pay attention to whether another kea put work into moving the log, or simply perched on the log and let them do all the hard work? As humans we understand how cooperation works: we know when we need a helping hand and when we don't. We also have a sense of fairness, termed inequity aversion in the scientific literature: we track whether we get fair reward for our efforts compared to others around us, and get upset if we are treated unfairly.

> "they would wait for the partner to arrive... so Kea seem to understand aspects of cooperation: they know when they need help, and when they don't"

While we did not find evidence of inequity aversion in the kea, the results from our studies on kea cooperation were really exciting. We gave the kea the cooperative pulling paradigm, which consists of food on a board with a rope running around it held on by hooks. If an animal pulls one end the rope will unwind through the hooks and come out. If it pulls both ends of the rope it will move the board towards the puller. Animals start off by learning to pull both bits of rope towards them to get the food. As test we put the two rope ends far and allow two animals to approach at the same time. We then observe if they pull the ends of the rope together to bring the platform within reach and get the food. We found the kea we tested spontaneously cooperated by pulling the two rope ends together so we ran more tests to try to understand what they understood about cooperation.

How long can a kea wait?

The next stage of testing was to see how well the kea could learn to wait for another partner: could they learn to wait for a helping hand? We began by releasing one kea first and then releasing a second kea a few seconds after and then gradually increased the release time for the second kea, as Josh Plotink did in a recent study on elephants. Josh showed that after training elephants were able to wait for longer periods than those they had been trained



Dear Parasites

A married psychologist-and-parasitologist team write

Stefanie K. Johnson *and* **Pieter T.J. Johnson** *are at the University of Colorado Boulder*

Thank you for letting us live in your world. Just as people once believed that the sun revolved around the earth, we have for too long believed that humans are the centre of the world and parasites were a nuisance to be inexorably conquered through medical advances. But viruses, bacteria, protozoa, parasitic fungi, parasitic arthropods and parasitic worms (i.e. 'parasites') comprise more than 40 per cent of all described species and have irrefutable effects on populations, communities,and ecosystems. While we tend to worry about big predators such as sharks and lions, it is parasites that represent the pinnacle of the food chain (some parasites even infect other parasites!).

We often focus on the role of predators in driving change. But how might have parasites affected human evolution, including our powerful immune systems or even our tendency to live in social groups? Some of our most basic human behaviours, like disgust, have been theorised (by Valerie Curtis and others) to be an adaptation to avoid parasite infection.

Now, I know you have gotten a bad rap for things like castrating your hosts, changing males into females,

with. The elephants in that study were tested up to a wait period of 45 seconds, so we went one further with the kea and examined how they did when having to wait for a partner for up to 65 seconds. They were able to wait that long, which is really impressive, as it suggests these parrots have excellent self-control. We also found they would only wait for a helping hand when they needed to. If we gave them a platform with the two rope ends close together they would pull them immediately rather than waiting for a partner, but as soon as the rope ends were far apart they would wait for the partner to arrive. So kea seem to understand aspects of cooperation: they know when they need help, and when they don't.

We also got a very interesting result from one bird, Neo, who's a bit of a superstar for us. In this final stage of our study we used a paradigm previously tested on chimps and children. Subjects had the choice of working alone or with another. We asked the same of kea: did they want to work together and pull a rope cooperatively with another bird or did they prefer to work alone? Past work had shown that while chimps show no preference between those choices, children strongly prefer to work with another child. This has led to the suggestion that one of the key difference between human sociality and that of other animals is that humans have a unique pro-social motivation to work together even if they don't benefit materially from it. But Neo showed the same preference as children, he preferred to work with other kea. So Neo's behaviour really brings that recent claim into question.

A key part of our work with the kea is focused on understanding their cognition so we can help in their conservation. Kea were recently reclassified as endangered as there are only 5000 to 6000 left in the wild. They face some big issues including invasive predators and lead poisoning. We've been talking to the Department of Conservation here in New Zealand and are going to run some studies looking at the basics of how kea learn and smell to inform conservation efforts. Fingers crossed we can help save this amazing parrot!

and killing more than a million humans each year (mostly through malaria). Your shocking ability to augment host behaviour – from fungus-infected 'zombie' ants to worm-infected crickets manipulated to go for a fatal swim – can make you seem like real monsters in the animal kingdom.

But what of parasites' impact on human behaviour? We have to look no further than the rabies virus that increases human aggression, or the influenza virus that increases sociability, to realise that our minds and bodies can also be controlled by parasites.

In our recent study, we examined the effect of a widely distributed parasite, *Toxoplasma gondii*, which infects over a billion people worldwide. Building upon previous research linking infection to increases in negative outcomes (schizophrenia, suicide, road rage and car accidents), we explored the parasite's influence on the human entrepreneurial spirit. At local (students, entrepreneurs) and global (across countries) levels, we found a positive link between infection and entrepreneurship. The data, although correlational, suggest that *T. gondii* is negatively related to a fear of failure for entrepreneurs, and therefore, an increase in the likelihood of starting a business. Whether the businesses started by infected individuals thrive or fail is yet unclear.

This potential benefit of a parasite sounds surprising at first. But other data also show that exposure to parasites can reduce allergies and autoimmune diseases through the hygiene hypothesis. The long-term effects of parasites on the human brain, a field we call parasite-psychobiology, has potentially far-reaching implications for our understanding of human behaviour.

Whether you love them, or hate them, one thing is clear – we shouldn't underestimate parasites. We have long considered parasites as passengers (or perhaps hitchhikers) on our evolutionary journey, but sometimes you have to wonder… who is really steering this bus?

Innovation in chimps

Competition, innovation and more

Dr Lydia M. Hopper
is Assistant Director of the Lester E. Fisher Center for the Study and Conservation of Apes at Lincoln Park Zoo in Chicago

Like humans, chimpanzees live in large dynamic societies, which are regulated by social norms and local cultures that may promote or inhibit innovation. Chimpanzee groups are composed of individuals who are each unique in terms of their personality and social standing. These individual characteristics also relate to their proclivity to innovate and their tendency to adopt the innovations of others. While innovation is often considered at the level of the individual – the genius innovator – it is equally important to understand the social world the innovator inhabits.

Consider, for example, a study that we ran recently with a group of chimpanzees housed at the Lincoln Park Zoo in Chicago where I work. In each test session we gave the chimpanzees 150 plastic tokens that they could exchange with two researchers for food rewards. We wanted to see whether the chimpanzees would be willing to take tokens to the researcher who stood further away in order to gain a more-preferred reward, and whether they could respond flexibly when we changed what foods were available where. We didn't train the chimpanzees how to exchange tokens, nor did we teach them about the relative value of the food rewards available at each location.

A male chimpanzee, Optimus Prime, was the first to exchange a token for a food reward and he did so with the closest researcher, gaining a piece of carrot. The majority of his group quickly learned his new skill, exchanging their tokens for the readily accessible, but not-so-desirable, carrot pieces. Competition ensued as the chimpanzees all tried to exchange tokens. This competition was felt most keenly by the youngest, and most low-ranking, member of the group: Chuckie.

In response to the competition, Chuckie innovated. She was the first in her group to discover that if she

Comparing chimpanzee and bonobo behaviour

A conversation between Kirsty Graham and Catherine Hobaiter

Dr Kirsty Graham
is a Research Associate at the University of York's Department of Psychology
Dr Catherine Hobaiter
is a researcher at the University of St Andrews School of Psychology and Neuroscience

KG: We're both primatologists, but I study bonobos and you study chimpanzees. I've always thought I'd much rather be a female bonobo than a female chimp, or a male chimp for that matter! Bonobo females have it pretty good – they eat first, decide when to travel, back each other up in a fight against males. Of course, there's a bit of variation depending on their place in the


Getty Images

carried her token a little further, she could get a better reward (a grape) for each token she exchanged. And she was the first to do so again in a later phase of the study when we moved the exchange locations. In contrast to teenager Chuckie's innovative nature, was the behaviour of the dominant male, Hank. Perhaps less in need of additional food given his rank, or his lack of interest in observing the behaviour of lower-ranking members of his troop, Hank only exchanged his first token after we had been running the study for a about year! Thus, although this trading behaviour was ultimately adopted by all group members, there was individual variation regarding how and when the chimpanzees exhibited this behaviour.

When we later replicated the study with our family group of gorillas, we saw again individual differences, but also stark species differences. Unlike chimpanzees, which are willing to share personal space allowing others to observe their behaviour, gorillas are less gregarious. Of the six gorillas we tested only two ever exchanged tokens, and the vast majority of exchanges were made by the silverback Kwan, whose dominance allowed him to guard access to the tokens.

The behaviour of the chimpanzees reflects that reported for wild chimpanzees: those most likely to innovate are typically males and/or young and low-ranking individuals. As someone who has had the fortune of studying primate behaviour for my career, this individual (and species) variation was not surprising. Each primate has their own personality. Indeed, my own research has revealed that chimpanzees rated highly on personality traits related to curiosity, exploration and persistence are more dogged in their efforts to solve novel puzzles. While this is theoretically interesting, it is also what brings most joy to me in my job. Through the relationships I build with the primates I study, I learn their unique personalities, preferences, and skills. Each animal is different, and this keeps me on my toes as a researcher designing tasks to study their cognition.

I have always been curious about what animals are thinking. As a young child I wanted insights into what my pets felt and thought. In school I studied Psychology A-level and almost right away I realised that this was the subject for me! Later, at Liverpool University, and determined to study primate behaviour as part of my Psychology and Zoology combined honours degree, I reached out to Chester Zoo to see if I could observe their orangutans for my final-year project. At the zoo I studied mother–infant interactions in Bornean and Sumatran orangutans, under the supervision of developmental psychologist Caroline Rowland. I realised my passion for research as well as my specific interest in comparative psychology.

In my role now I oversee cognitive and behavioural research with the chimpanzees, gorillas and Japanese macaques at Lincoln Park Zoo, again providing me with a comparative perspective – when and how individuals innovate or use social information and how species differ in their use of social information. I use touchscreens and eye-tracking devices in addition to manual tasks to answer my research questions. Being at a zoo also offers the relative unique opportunity to run studies in view of visitors – to share not just what we learn, but how we study primate cognition.

hierarchy but female bonobos seem to generally be much more sociable and central. What's your impression from the chimp side?

CH: You're right, bonobos have life pretty well worked out! Especially the girls. Mature male chimpanzees outrank everyone else in the social hierarchy, and they can be extremely aggressive, including killing individuals in their own group. So there is a perception that female chimpanzees have less agency in what goes on in their own or the community's day-to-day life. But that's definitely not the complete picture.

Females regularly rebuff the sexual attentions of males – from giving little more than side eye to the teenagers trying out their first gestural 'pick up lines' to chasing a high rank male down a trail with his (proverbial!) tail tucked between his legs. Some is more subtle manipulation: chimpanzees 'exaggerate' the aggression they're experiencing depending on who might overhear their screams, and they seem to avoid using signals that reveal their identity when there might be eavesdroppers nearby.

KG: Yes! What I really love about comparative work is getting to work closely with two or more species and seeing where the variation is. Bonobos and chimpanzees both get painted with broad brushes, and it's so satisfying to pick apart what the similarities and differences really are and where they're coming from. Take gestures, for example (of course that's what two gesture researchers would say!). Bonobos and chimpanzees share about 90 per cent of gestures and many of the gestures share the same meanings. But if you listen to a bonobo call and a chimp call they sound really different. It's kind of odd. If we were expecting any differences in gestures too, where might we find them?

The magnificent, deft gorilla

Looking for shared characteristics

Richard W. Byrne
is Emeritus Professor at the University of St Andrews

Hard going keeping up with the tracker over unstable soggy vegetation; ancient moss-covered trees, red bark, silent; sounds of crashing about, and a *pok-pok-pok-pok-pok* sounding more like a woodpecker than a chest-beat. Then, quite suddenly, there are mountain gorillas all around, the adults largely ignoring us, the youngsters nervously curious of new faces. It ought to feel a bit frightening, but it doesn't.

This experience is shared now by hundreds of 'gorilla tourists', part of the conservation effort to save the species by giving Rwandan gorillas economic value. But in 1984 it was a rare privilege, granted to my wife Jen and me by Dian Fossey because we had been

CH: I know! We recently did an analysis where we explored if the overlap in the gestural repertoires existed only because all apes have a similar body plan and use all possible movement + limb combinations. But we found that chimpanzees use a tiny fraction of the potential gestures available to them – just 12 per cent, which makes the almost perfect overlap with bonobos' gestures even more striking. There's so much space for more variety – but they either can't or don't need to exploit it for communication. But if we're looking for differences we might learn something by looking at human speech. Different languages and dialects are incredibly varied and diverse, but they're based on the use of a universal shared set of phonemes. These are then recombined, or expressed in very different ways, to produce languages as different as Japanese and French.

Something that I think we're still coming to terms with as ape researchers is the massive variation within the species we study. There's no such thing as a 'chimpanzee typical' strategy towards even important social behaviour like negotiating rank or sex. Subspecies, communities, generations, and individuals all differ. You can take one chimpanzee and bonobo group and they'll look very different – a species difference? But switch out the chimpanzee group for a different one and suddenly they're much more similar. I know chimpanzee populations are larger and occupy more varied habitats right across east to west Africa, but do you think we'll see similar group differences in bonobos as more and more are studied?

KG: Yeah, inter-group differences for bonobos is a definite possibility. I worked with two neighbouring groups of bonobos who encounter somewhat regularly, and females immigrate between groups, so you might expect that their gesture repertoires would be similar. It would be incredible

researching chimpanzees in nearby Tanzania. A few years later, she had been murdered, and Jen and I were back at her study site, Karisoke, this time with a research project to tackle.

Great fun, no doubt, but why on earth should a *psychologist* be interested in gorilla behaviour: surely, we know plenty about chimpanzees already, and they're closer relatives to humans anyway? That is a common reaction, but it misses the point of how comparative evidence should be used to understand the evolutionary history of our species. Neither chimpanzees, gorillas nor any other animal is a 'living fossil' of a human ancestor, unchanged since their lineage diverged from ours. The idea that comparative psychology can reconstruct the human evolutionary path by studying only chimpanzees, rhesus monkeys, rats and pigeons is just misled: no species evolved to be a convenient 'model' of any stage in human evolution. What we need to do is look for *shared* characteristics of species within a group sharing a common ancestor (a clade, technically), since the most likely reason for characteristics to be shared is that they were inherited from the common ancestor. The characteristics can as easily be cognitive abilities as bone structure, the same logic applies. Thus, if chimpanzees, bonobos and ourselves share some ability, likely we gained it from the last common ancestor all three share (the LCA_chimpanzee – that is, the last common ancestor that we humans share with the living chimpanzee and bonobo; the 'LCA_bonobo' is the same), because those three species form a clade. However, that doesn't tell us where the ability arose: maybe the LCA_chimp inherited it from their ancestors – in other words,

to compare the gesture repertoire from Wamba with that at LuiKotale. These are currently the two best established field sites for bonobo research, and are the best candidates for comparison. But Kokolopori is another site where the bonobos are becoming better habituated too, so there might be opportunities for a large-scale group comparison.

Bonobos actually have a fair bit of habitat variation, from those living in deep primary forests; to those who live closer to human communities that experience more secondary forest; to those living in forest-savannah mosaic habitats. We are just starting to learn about the behaviour of bonobos in savannah mosaic habitats near Malebo and Lac Tumba. For gesture research, it could be particularly interesting to ask whether in more open savannah habitat where visibility is better they use different gestures than in forests of varying density. These large-scale comparisons require so much long-term data from so many places that it's impossible for you and me to collect everything – that's why international collaboration is so important to scientific research!

CH: Awesome! I didn't realise that there were also bonobos with some savannah habitat – could definitely have big implications for their communication. All vocalisations are audible, but gesture gives you the option to select signals that share information in different or multiple modalities (hearing, sight, touch). So many fun questions still to explore! I love that new technology is allowing researchers from sites around the world to work together and solve these really big puzzles (and it's a good excuse to spend more time than I should on Twitter). Bye for now! [*pant hoooots*]

KG: Bye from me too! [*branch drag into the distance*]

perhaps the ability is more primitive. To find out, you need equally good data from the next closest relatives: in the case of the human/chimpanzee clade, that's the gorilla. Suppose the gorilla does show the same ability, that means it had evolved by the time of the LCA_ gorilla; and to find out if that's when the ability arose, we again need to fan out to slightly less closely related species – in this case, to orangutans. Chimpanzees have indeed been very well studied, in the lab since early in the 20th century, with the work of Köhler and Yerkes, and in the field since the 1950s, with the work of Jane Goodall and others. Gorillas, on the other hand, are relatively neglected, and since their data is just as important to evolutionary reconstruction of humans, their study is more urgent.

Scientifically important and great fun

I was surprised at my own first reactions to gorilla behaviour. At that time, it was generally understood that the gorilla was the chimpanzee's slow-witted cousin, magnificent but dull. Coming from months in daily contact with wild chimpanzees, I was instead struck by how *similar* they seemed in most ways. Over the few weeks we spent with them in 1984, we were treated to a series of conflicts between groups, between lone males and breeding groups, and within the large groups themselves: some violence, but also skilled manoeuvring, team-work, and tactical deception. Gorillas were evidently socially sophisticated, so perhaps it is in the sensorimotor domain that they lag? Certainly, there was no sign of the elaborate and refined tool-making already known from many chimpanzee field-sites. Yet, when I watched the gorillas eating their plant foods, it was not the 'grab and shovel in' approach that most sources at that time described: gorilla eating looked deft and clever.

That observation led to our later study, in which we showed that the plant-processing was exquisitely devised to overcome physical problems of the nutritious plants – like stings, spines and inedible hard casing. Each plant's technique was a sequentially ordered, multi-stage program in which the two hands often took different roles, coordinated together to achieve single results, and in which several successive operations in the overall process could be iterated as a 'subroutine' to build up a decent-sized handful, something which relies on the gorilla motor skill to control parts of a hand independently. Moreover, these techniques were found throughout the local population, yet they would be useless elsewhere in Africa since each was specific to a plant that only occurred in the tiny area of the Virunga Volcanoes.

The social dog

How have we shaped them, and them us?

Dr Juliane Kaminski
is Senior Lecturer at the University of Portsmouth

When I was an undergraduate student I had a dog, Ambula. Ambula had a habit, which many dog owners are very familiar with. He was a very well-behaved dog but would steal food, the second I turned my back. I was always very interested in how animals make sense of the world they live in, especially their social world. I am particularly interested in the question of what animals understand about others, others' beliefs, desires, knowledge states and to what extend their understanding of others is similar or different to that of humans. Ambula's behaviour annoyed me as a dog owner but fascinated me as a scientist. Could it be possible that he really understood anything about another individual's visual perspective? That he understood that because I turned my back I could not see? Or had he just learnt a simple rule, seeing the human's eyes as some sort of aversive stimulus that if not visible meant he could do whatever he wanted.

We showed that, like chimpanzees, gorillas can build up remarkable technical skills, from a combination of individual and social learning, to tackle challenges presented by feeding; the only difference is that one species sometimes uses tools, the other never does. This puts a very different complexion on the best reconstruction of how humans developed the sensorimotor planning abilities on which so much of our culture depends: a quantal jump at the LCA_chimp stage, restricted to the context of tool use, is certainly not what happened! We need to look much earlier in the human lineage, at least back to the time of the LCA_gorilla, maybe earlier.

So, gorilla research is scientifically important – yet it must be admitted that it is also, er, great fun. Every night when comparing notes with other researchers over a shared meal, the topic of conversation was usually the soap-opera of gorilla lives: 'You wouldn't believe what Ziz did today! That wee cutie Umarava is getting too big for his boots, he'll be in big trouble soon. Effie and her daughters are terrible bullies, the new female in group five is having a terrible time.' Beats *The Archers* any day. And working every day with huge apes who look you in the eye, completely trusting – except when they think you might want to eat the same thistle – is a huge privilege. The mountain gorilla is the only ape species that is *not* currently in serious or catastrophic decline, thanks to the efforts that Dian Fossey originally set in motion to protect them. But their state remains fragile, and I can only hope that their few refuges remain safe havens for ever.

In an experimentally controlled study we showed that indeed, even under these conditions, dogs very much distinguish between a human looking at them with their eyes open and a human not looking with their eyes closed. Dogs stole forbidden food when the humans eyes were open but significantly more when the humans eyes were closed. We also showed that human attention mattered for dogs during other communicative interactions. For example, dogs produce more facial movements when a human is looking compared to a situation during which the humans back was turned to the dog. Interestingly, presenting food to the dogs did not have the same effect, indicating that it is not sheer arousal that makes the dogs move their face, but facial movements might be a communicative signal that dogs produce more when someone is looking. I would not say that we have a conclusive answer to the question to what extent dogs understand seeing in others… this question, among others, will most likely keep me busy for quite some time in my scientific career.

Ambula had other habits that caught my (scientific) attention. He would come when I called him. He would look at me when I called his name. He would pay particular attention when my voice was high-pitched while calling him. When I threw the ball for him and he did not see where it had ended up, I would show him by pointing towards it and he would easily follow my gesture. As a dog owner, I thought that's just what well-trained dogs do; as a comparative psychologist, I was excited as I was observing the reason why dogs are such a highly interesting model species for comparative psychology. So interesting that even Paul Bloom said 'for psychologists dogs might be the new chimpanzees'. This is because research over the last decades has shown that what Ambula was doing during these interactions was the result of dogs' adaptations to the human environment. During domestication domestic dogs have evolved social cognitive skills, which seem functionally equivalent to those of humans.

> "Dogs seem to have adapted to their unique environment in ways that cannot be found in any other animal, including other domesticated animals"

A social tool

Dogs are the first species humans domesticated, more than 30,000 years ago, and some researchers think dogs helped us become the species we are today. This is because during our joint evolutionary history, dogs made our lives easier. They bonded with us. They made hunting easier. They made herding easier. So they helped us to survive. But that's not what fascinates me so much. What fascinates me is that during that time dogs seem to have adapted to their unique environment (the human environment) in ways that cannot be found in any other animal, including other domesticated animals. Dogs use and follow human communication in ways other animal species do not. Dogs follow human gestures, like pointing, and do so more successfully than any other animal: including humans' closest living relative, the chimpanzee. And this is not the result of mere learning during ontogeny, as already very young dog puppies show similar skills. During communicative interactions with humans dogs pay particular attention to the human's eyes and ignore human gestures if no eye contact with the human was established. They do not just follow the movement of the human's arm as a stimulus; a communicative context has to be established first.

Humans have consciously or unconsciously 'created' a species that reacts to human communication flexibly and sensitively, and most likely that's what made dogs the 'social tool' that was so useful during several human activities.

For me, working with dogs is highly rewarding. Not just because they are such an interesting model species, but also because it gives us the opportunity to involve members of the public, the dogs' owners, in our research.

How I went to the dogs

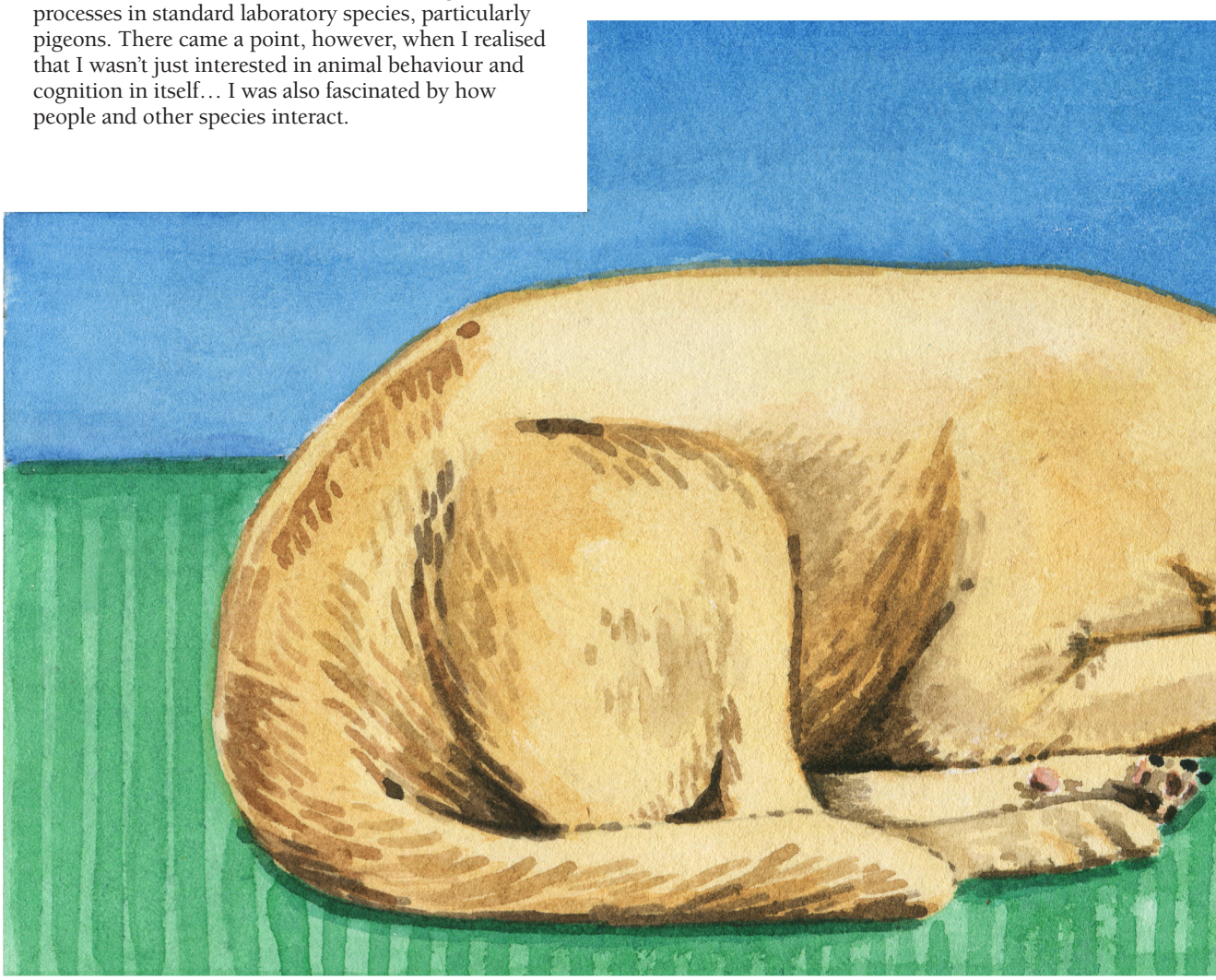
The path from 'teenager with dog' to 'middle-aged professor studying dogs'

Professor Clive D.L. Wynne
is a researcher at Arizona State University, in Tempe

When I was a teenager I honestly thought nobody understood me as well as my dog, Benji. Like a lot of kids that age, I sought solace in the silent support of a beast from a species that many call 'Man's best friend'. That might make it seem inevitable that as an adult and a professor of psychology I would be drawn to studying the behaviour of dogs and what makes it possible for them to occupy such an important role in so many people's lives, but actually the path from teenager with a dog to middle-aged professor studying dogs was anything but straightforward.

Certainly, I knew from quite early on that I wanted to study the behaviour of nonhumans. As a student, I was inspired by several great teachers (particularly Henry Plotkin) to try to understand how psychology fits into evolution. How do minds evolve and how much of the human mind is unique? This led me towards studies of basic behavioural and cognitive processes in standard laboratory species, particularly pigeons. There came a point, however, when I realised that I wasn't just interested in animal behaviour and cognition in itself… I was also fascinated by how people and other species interact.

It was around this time that, after having been missing from the psychological literature for a few decades, dogs were experiencing a revival of interest from behavioural scientists. In the late 1990s, Brian Hare (then a student at Harvard) and Ádám Miklósi (an ethologist at Eötvös Loránd University in Hungary) independently started publishing very thought-provoking papers on how dogs respond to human cues. In an experiment that became archetypal, a human pointed at one of two objects on the ground while the dog watched. If the dog chooses the container the person points at, it gets a treat; the other container is empty. Dog lovers will not be surprised to learn that the dogs typically choose the container the human has pointed towards, but this was a bigger surprise to the comparative psychology community because captive great apes typically fail on this kind



of task. Hare and Miklósi each also tested hand-reared wolves on the same procedure. All of our modern dogs are descended from wolves, so comparing dog behaviour to that of their wild ancestors informs us about the evolutionary origins of their behaviour. Both Hare and Miklósi found that wolves failed the pointing test, leading Hare to conclude that, during domestication, dogs had evolved unique forms of human-like social cognition. Hare went on to argue that the ability to respond appropriately to human social cues like pointing gestures was innate in dogs and not found anywhere else in the animal kingdom.

This strong claim for cognitive uniqueness in a nonhuman's relationship with our own species excited me tremendously, and I set about replicating the very simple tests that Hare and Miklósi had originated. Initially, the work that my then student Monique Udell (now assistant professor at Oregon State University) and I carried out matched exactly what Hare and Miklósi had reported. We too found that pet dogs would follow a human point to find food in a baited container. But once we had the opportunity to test hand-reared wolves, we found that our results quickly began to depart from theirs. The wolves we tested were just as good at following pointing gestures as any dogs, and, as we moved on to test more diverse populations of dogs, we quickly found groups of dogs that did not spontaneously follow pointing gestures. At the animal shelter, for example, we found the vast majority of dogs did not spontaneously follow pointing gestures.

These surprising findings have been the jumping off point for all my subsequent research projects.

A unique relationship

Our first forays into our local animal shelter opened my eyes to the dark underbelly of our lives with dogs – the millions of animals that are unceremoniously dumped as surplus to human requirements. We found that, although they do not spontaneously follow human gestures, they can quickly be taught how to. Our subsequent research has focused on finding ways to help these dogs get adopted by studying what behaviours attract and repel potential adopters, and how to change them. We are also looking at what makes shelter life stressful for dogs and finding ways to mitigate that stress.

Although we do not agree with Hare and others who have claimed that dogs show unique cognitive adaptations to living with humans, I continue to be fascinated by how dogs thrive around people and what behavioural adaptations make that possible. We have recently found that dogs share genetic changes with people who have Williams-Beuren syndrome. WBS is a very rare disorder with a wide range of symptoms, the most striking of which is extreme gregariousness. People with WBS treat everyone they meet as a friend – just as so many dogs do.

We have also been applying behaviour analytic techniques to improving the behaviour of dogs in people's homes and in the training of bomb detection dogs. Sniffer dogs do not just figuratively save people's lives, they literally protect people from deadly threats, and yet the techniques that are used to train them have developed very little over the past 50 years.

Benji, of course, has long gone off to that great dog park in the sky, but he lives on in my mind as an inspiration to understand this unique relationship between two species, a relationship that, at its best, can greatly enrich both partners, and which psychologists are uniquely well qualified to facilitate.


Getty Images

Food and the human–animal bond

Improving welfare for our animals is good for us too

Dr Zazie Todd *writes the evidence-based Companion Animal Psychology blog at* **www.companionanimalpsychology.com**

I was a cat person first. As a child, I was terrified of dogs. But I've come to love dogs just as much as cats, and now I'm always watching them. The lovely open-mouthed 'smile' of a happy dog, a lick of the lips (in response to stress, not food), the carriage of the tail (high, low or in-between) are just some of the signs that help us infer how a dog is feeling.

But we know many people miss the signs of fear and stress in a range of different contexts. This can have consequences for the dog's welfare, because their guardian cannot help them out of a stressful situation if they don't realise it is stressful. But it can also have consequences for the person's relationship with their dog. And while we like to think of dogs as our best friends, sadly some human–canine relationships break down.

On my blog, Companion Animal Psychology, I write about the science of people's relationships with their pets. The topic that gets the most engagement from readers is dog training, and specifically dog training methods. Since behaviour problems are the main cause of death of dogs under three-years-old, getting dog training right (as well as proper socialisation of puppies) would make a big difference.

Of course, psychologists know about operant and classical conditioning, which are the foundation of how we train dogs. And we have an ethical choice, to use reward-based methods or those that rely on aversives. Last year, two reviews of the literature concluded that, although more research is needed, reward-based training methods are better for animal welfare. One of them suggested reward-based training may also be more effective, since people who use it report more obedient dogs.

Yet we know that most people use a mix of both positive reinforcement and positive punishment to train dogs. I explore the reasons why some people are reluctant to use reward-based methods in a paper in press at the *Journal of Veterinary Behavior*. Some dog-training books and TV shows still recommend aversive methods, such as prong collars and 'alpha rolls' (pinning the dog down on its side). If people aren't good at spotting signs of stress, they may not notice if the methods they use are stressful for the dog. Different organisations take different positions, and when aversive methods are recommended as a 'last resort', it may give the mistaken impression that sometimes they are necessary. We also don't know how people make decisions if they think positive reinforcement isn't working (e.g. to use aversive methods or refer to someone else with more experience). The theory of planned behaviour would be a good approach to get a handle on people's attitudes and intentions to use particular methods. I would love to see more psychological research on this, as well as on the ways people talk about dogs, in particular the use of wolf-pack metaphors.

One of the things about reward-based training is that the reinforcer has to be something the dog will work for. In my experience, many people are reluctant to use food as a reward and prefer to use praise such as 'Good dog!' Perhaps one reason is that for so long we have been told the myth that you just have to be the 'pack leader'. This makes using food (like little pieces of chicken) to train dogs seem like a weakness, when in fact it's a sign of someone who knows how to motivate a dog.

Unfortunately, praise is not reinforcing to dogs unless it has already been conditioned. A nice series of studies by Erica Feuerbacher and Clive Wynne look at what dogs like when they are given a free choice, e.g. between one person who will pet them and one who is offering praise. Dogs preferred to hang out with the person who was offering petting. In an earlier study, they found that food is a better reinforcer than social interaction (petting) in dogs and hand-reared wolves.

Much of the research on pets has focused on the question of whether or not they are good for our physical and psychological health. But it's important to also consider the everyday interactions people have with dogs and how they shape the human–animal bond. For both dogs and cats, there are misunderstandings about what they need and how to train them (yes, even cats can be trained!). I like to think that improving welfare for our companion animals is good for people too.

All illustrations by Adam Batchelor (www.adambatchelor.co.uk).
Find sources and further reading with the online version of this feature.

Work with a species we haven't covered? We want to hear from you! Email **jon.sutton@bps.org.uk** or tweet **@psychmag**. And look out for a piece from John Cryan in the coming months... are we in fact living in a microbial world?