Of Parrots and Parsimony: Reconsidering Morgan's Canon

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Abstract

Morgan's Canon is a specific restating of Occam's Razor that dictates that any description of animal behavior should never call upon higher order psychological processes if the behavior could, fairly, be explained in terms of lower processes. Herein, the Canon is discussed both historically and in light of current research into animal behavior. A reconsideration of the principle of parsimony, taking into account current states of knowledge, is also considered. In short, it is argued that Morgan's Canon, while a useful guideline, may have been over-enthusiastically applied in situations where the state of knowledge about a species would dictate that descriptions of its behavior in terms of higher order processes would be equally or more parsimonious. The potential benefits of reconsidering the Canon are then discussed.

Keywords: parsimony; animal behavior; comparative psychology; theory of mind; individual differences.

Morgan's Canon

In no case is an animal activity to be interpreted in terms of higher psychological processes, if it can be fairly interpreted in terms of processes which stand lower in the scale of psychological evolution and development. (Morgan, 1903).

Comparisons between animal and human behaviors have a long history, with scholars as far back as Aristotle (340BC/1952) arguing that 'reason' divides humans from the rest of the animal kingdom. This division, embedded in the Christian distinction between the creation and place of men and animals, was carried through the writings of such philosophers as Descartes (1640/1988) who placed the seat of reason in the soul; and little seems to have challenged this view until the publication of Darwin's Origin of Species (1876/1988).

The arguments presented by Darwin, regarding the common descent of all animals through natural selection acting on ancestor populations, broke down the clear-cut division between human and animal that had previously held sway in Western thought and promoted the idea that, across species, one should expect to see variation in traits – including such mental attributes as intelligence (Darwin, 1899/1965). Thus, while humans might be the species blessed with the greatest reasoning ability, one would expect that other species would have this to a greater or less extent – with the further understanding that closely related species would, likely, have similar levels of intelligence.

Romanes (1882), following this parsimonious line of reasoning, produced his book *Animal Intelligence* in which he described a great variety of animal behaviors (both collected by himself and sent to him by correspondents) in terms of the mental states and understanding required to produce them. The anecdotal nature of this work, however, provoked the responses of Morgan (1903) and Thorndike (1911), whose use of observational study of animals convinced them that many of the cases of 'intelligent' behavior reported by Romanes were, in fact, easily explained as the result of trial-and-error learning.

The reaction to Romanes' book and the subsequent research on conditioning by Pavlov (1927) led to a drastic change in approach to animal behavior research. Rather than considering the pre-existing knowledge of common lineage, researchers were, instead, motivated to explain behavior in the simplest, possible psychological terms. This was partly the result of a genuine belief in the equipotentiality principle (Pavlov, 1927) - which regarded all animals as largely equivalent in terms of their ability to learn through conditioning – but seems also to have resulted from a revision of people's interpretation of the principle of parsimony with a greater focus on the simplicity of the explanatory rules and less on the need for accord with prior knowledge.

Thus, for the greater part of the 20th century, Morgan's Canon has held sway - and been interpreted to mean that animal behaviors should be explained, wherever possible using simple, conditioning-based explanations as these were judged to be most parsimonious and, thus, best.

Occam's Razor and Parsimony

Parsimony in scientific research is often regarded in terms of Occam's Razor, which literally translates as "entities must not be multiplied beyond necessity" but is commonly understood to mean that the simplest hypothesis explaining an observation is the best (Kneale & Kneale, 1962). However, this simple restatement ignores the key phrase in the original: "beyond necessity". Thus, a more complete restatement would require that the best explanation be the simplest one that accords with our state of knowledge about the object or event in question.

The relevance of this to animal behavior research is that, when considering the most parsimonious explanation for an animal's behavior, we must take into account what we already know about that species, related species and even animals in general. Imagine, for example, if one were to see a small animal (of an unfamiliar species) moving along the ground and were interested in starting to explain its behavioral repertoire. Starting with the very broadest of behaviors, for example, we might ask whether the creature's appearance in this location is indicative of its environmental predilections and behaviors.

That is, is the simplest (most parsimonious) explanation for its presence that it is a terrestrial creature native to the area? The answer, in the absence of additional information should, clearly, be yes – this is the simplest explanation that explains the limited data we have. It does not require us to hypothesize about any alternative modes of movement beyond the observed, terrestrial movement nor does it require an additional explanation about why a non-native creature might be here.

If, however, while still unfamiliar with the species in question, you recognize that it is a type of bird this would, almost certainly, change the description judged most parsimonious. Given a general knowledge of birds, it would seem reasonable to decide, instead, that the most parsimonious explanation is that the creature is capable of flight and only currently on the ground – as the vast majority of birds are capable of flight. To take the example a step further, imagine that, in addition to recognizing the creature as a bird, you also recognize that it is, in fact, a type of penguin. This would cause another revision in the best explanation for its behavior (current and potential); in this case, concluding that it is, most probably, flightless and aquatic - as are all other penguin species.

Thus, knowledge about related species changes both the description of current behavior and *expected* behavioral repertoire of an animal; and, any attempt to find the *simplest* (most parsimonious) explanation for an animal's behavior must incorporate this knowledge.

Animal Cognition

Few people, of course, would disagree with the above examples and ethologists such as Tinbergen (1951) and Lorenz (2002/1949), despite their largely behaviorist view-points would, doubtless, start any observations of a new species with assumptions regarding its behavior based on the behavior of known, related species. The behaviors described by ethologists and those considered of greatest import by those comparative psychologists holding to Morgan's Canon, however, differ in significant ways. For the most part, ethologists deal with general types of instinctive behavior in the natural environment whereas comparative psychology concerns itself with animal cognition to gain insight into human cognition. That is, to what extent are animals capable of reason, learning and self-awareness and how can this knowledge be used to better understand human behavior?

As noted above, the behaviorist school of psychology (see, e.g., Skinner, 1938) applied Morgan's Canon uniformly and attempted to explain both human and animal behavior in terms of conditioned responses as the equipotentiality principle argued for all organisms learning in, essentially, the same fashion with differences only in the speed at which learning occurred.

The cognitive revolution, starting in the 1950s, however, convinced most psychologists that attempts to explain complex, human behaviors such as language use within a simple, reinforcement-learning paradigm was infeasible (see, e.g., Neisser, 1967). Perhaps the single greatest effect of this revolution was to move psychology away from regarding the mind as a black box about which nothing could be known beyond inputs (stimuli) and outputs (observed behaviors). Instead, it was recognized that: firstly, the mind cannot be a blank slate prior to learning because a blank slate will not react to inputs in any way (for a recent summary of the cognitive revolution, see Pinker, 2003); and, secondly, that observing the manner in which behaviors change as stimuli change allows us to meaningfully hypothesize about cognitive structures/processes.

This recognition of the need to understand an organism's cognitive processes or mind was not restricted to humans, however. Breland and Breland (1961) identified instinctive drift (the tendency for animals' trained behaviors to revert to the nearest equivalent instinctive behavior) and Garcia and Koelling (1966) exposed the difficulties of training animals when the conditioned and unconditioned stimuli did not 'match' (e.g., illness could be induced in rats by a flavor but not by a light or sound). That is, it was demonstrated that, in order to predict and understand experimental results, one needs to know not just the stimulus and resultant behavior but also the cognitive processes of the organism in question.

Despite such work, however, the shift from behaviorism to cognitive psychology stalled in animal research – no doubt partly because access to human cognitions is often as easy as asking someone what they are thinking while animal minds are much harder to read; but also, it seems, due to a continued belief that the most parsimonious explanation are those that posit the simplest possible processes without reference to 'human' cognitive processes (see, e.g., Wynne, 2007).

The question, though, how *should* our understanding of parsimony affect our beliefs regarding the best explanations for animal behaviors in terms of psychological processes? This is discussed in greater detail as regards two central areas of animal cognition that have provoked significant discussion: animal intelligence and theories of mind.

Animal Intelligence

Between Species Differences

Most people have very little difficulty in believing that certain types of animal are more intelligent than others. This seems to be one case where our understanding of the concept of common lineage has led us to conclude that animals more like us are likely to be more intelligent; and experimental work has offered some support for this. Work by Warren (1977), for example, comparing fish, chickens, mice and cats on a learning task returned the expected order of results – with the cats performing best, then the mice, the chickens and, finally, the fish – although only the cats performed significantly better than the other species.

The problem with such assessments, however, is clear. The very differences described by the Brelands (1961) and Garcia and Koelling (1966) make cross-species comparisons difficult as differences in instinctive behaviors mean that certain species learn particular tasks more easily, thus making it difficult to determine whether any differences result from differences in "intelligence" or just differential degrees of match between a species and the task/apparatus being used.

Individual and Strain Differences

To avoid these problems, most researchers concentrate, instead, on within-species analyses as these should eliminate most differences in instinctive behavior and allow meaningful conclusions to be drawn. However, between research into human and animal intelligence lies a vast gulf - in the form of differential treatment of individual and group differences within a species.

In human research, individual differences is a major field of research, while group differences are very much a sideline – a result, Fraser (1995) argues, of the feeling that research into group differences in intelligence (in particular) is motivated by prejudice. By comparison, animal research is dominated by comparisons between strains of the same species – with tests of such attributes as spatial ability, memory and even reasoning using pigeons (Wilkie & Wilson, 1995), mice (Tang, et al., 1999) and rats (Anderson, 1992), respectively. These often include neuroanatomical studies to associate the cognitive differences with particular brain structures (the hippocampus, for example, is strongly linked to spatial learning by the above studies).

Individual differences in animals, by comparison, have been largely ignored or even dismissed – as by Warren (1977), who claimed that there was no evidence of individual animals performing above the level of their peers. This dismissal, however, seems to be driven, in part at least, by adherence to the narrow interpretation of Morgan's Canon described above. That is, individual differences in animal intelligence are not discussed because intelligence (which is largely understood in terms of studies of individual differences in humans) is regarded as a 'higher' order cognitive process and, therefore, inappropriate to apply to animal behavior.

This position, however, is at odds with both our everyday experience – those people who interact with animals on a regular basis such as animal trainers and researchers are adamant that certain, individual animals are smarter than others (see, e.g., Goodall, 1968; Kohler, 1925; Pepperberg, 1990) – and knowledge available to us from a variety of fields, including evolutionary theory and the strain differences studies mentioned above.

The first point, of course, relies on the same anecdotal evidence that led to the formulation of Morgan's Canon and runs the risk of the Clever Hans effect (Pfungst, 1911) where the trainer's own unconscious behavior is responsible for apparent differences in learning. As such, it must be treated with caution.

The second point, however, argues strongly for there being individual differences in animal "intelligence" – broadly defined here as any cognitive faculty affecting performance on a task. Specifically, according to the theory of evolution by natural selection, it is individual, genetic differences in traits that cause differential survival and (eventually) speciation (Darwin, 1876/1988). As such, if the argument is to be made that there are differences between the cognitive abilities of different species (for example, that humans have better reasoning abilities than other species) then these differences must have their origins in individual differences within the ancestral populations from which the compared species are descended (Griffin, 1976). Thus, in the ancestral species from which humans and chimpanzees are both descended, there must have been individuals with better reasoning abilities than their peers – otherwise these reasoning abilities could not be selected for and, thus, contribute to the evolution of differences between humans and chimpanzees.

Logically, this argument holds at every point of speciation where one believes there is a difference in cognitive abilities between current species. While this argument does not, in and of itself, make any statement regarding individual differences within *current* species, any attempt to argue that individual differences might, no longer, exist in species other than our own would seem so unlikely as to strain credibility. That is, the claim would have to be that: while, at every point in the past, individual differences in cognitive ability existed within a wide variety of species, now, for unexplained reasons, only one species has such individual differences.

In addition to the argument from parsimony proposed above, we also have evidence for individual differences in cognitive abilities in the form of our ability to selectively breed strains of a species for particular cognitive tasks such as maze-solving (Stewart, 1961); and the observation that strain differences are known to exist on a variety of tasks including those described above. Given the derivation of these strains from common, ancestor populations, it seems unavoidable to conclude that individual differences in the various cognitive abilities discussed do exist and that strain differences are just these writ large.

In addition to these logical arguments, there are also a number of studies (see, e.g., Anderson, 1992; Locurto & Scanlon, 1998; Welsh, 2002) that have shown individual differences in the performance of not just specific tasks but also the emergence of factor structures amongst various tasks reminiscent of the structure of human intelligence as described by Carroll (1993). Specifically, there is some evidence for attributes akin to human spatial intelligence and memory and learning (*Gv* and *Gy* in Carroll's model).

Given this, it seems reasonable to argue that, when attempting to explain animal behavior, appeals to differential levels of cognitive ability between individuals is not an 'unnecessary multiplication of entities' nor does it violate Morgans's Canon as, given the evidence for individual differences in various cognitive abilities, animal behavior cannot be *fairly* described without reference to such higher order cognitive constructs. In fact, any explanation for an animal's behavior that excludes this knowledge is likely to be overly simplistic rather than parsimonious.

Animal Theories of Mind

Another area of argument in which Morgan's Canon is frequently applied regards whether animals have a 'theory of mind'. That is, to what extent should animals be regarded as possessing minds in the way that humans do; are they self aware and aware of the minds of others (Premack & Woodruff, 1978)? A number of tests of this are commonly used and interpretations of experimental results are often hotly debated in terms of whether the behavior of the animals in questions indicates a theory of mind or can be explained via simple, stimulus-response relationships.

The goal, herein, is not to attempt to fully restate the debate; rather, key aspects of the debate will be considered along with findings relating to these and the interpretations will be discussed in terms of their parsimony in explaining not just the specific behavior at hand but also prior knowledge including phylogenetic relationships.

Attention

One of the preliminary tests for a theory of mind relates to whether an organism reacts to another organism's attention. That is, if one animal is looking in a particular direction, will the other animal look there as well. This is regarded as a test of an organism's theory of mind as it, theoretically at least, requires that the second organism be able to determine where the first creature is looking and what it could see from there.

For example, chimpanzees have been shown to understand point-of-view – that is, their behavior changes according to what an observing creature could see from its perspective (Hare, Call, Agnetta, & Tomasello, 2000). Further tests of this ability to understand attention have included observations of canine communication, where dogs' behaviors are affected by whether they can currently be seen by other dogs (Horowitz, 2009) or people (Call, Brauer, Kaminski, & Tomasello, 2003).

These tests of attention, however, are often criticized (in terms of their relevance to animal theories of mind) as their results can be explained in terms of selective rewards. That is, in environments when a human is directly facing them, a dog is more likely to have been punished for disobeying a command than when a human is facing away. Thus, differential learning could occur such that greater obedience is observed when the dog-human dyad is in certain spatial relations but not in others. This explanation requires only simple psychological processes to be hypothesized and, as a result, is often claimed to be a more parsimonious interpretation of animals' apparent ability to understand the attentional states of others.

Whether it is, in fact, a simpler explanation, though, is questionable. For example, the ability of the dog to distinguish between the situations when a second creature is and is not looking at it – as required by the stimulus-response explanation – requires the dog to have been in sufficient situations like this one to have learnt the difference between the various orientations of other creatures and their responses to various communication methods. That is, it pre-supposes a history of learning for which no evidence is presented.

Further, given that we know that one social mammal (humans) definitely has the ability to determine where another creature is attending (which assists with social communication and cooperative behaviors), should our starting assumption be that a species bred from another highly sociable mammal (wolves) and further selected for its ability to cooperate with humans does or does not have the same ability?

Imitation

Another central theme is theory of mind research is imitative behavior. That is, if an organism can observe another organism and then *imitate* the behavior, then this is argued to indicate its ability to understand the intentions of the first creature. Of course, there are provisos added to this simple description. The observer must be able to distinguish between accidental and deliberate behaviors and must also be able act in an intentional way – that is, the assumption must be that the organism's goal in imitating the behavior is to achieve the *outcome* that they observed the other creature achieving – rather than to simply mimic the action (Tomasello, Kruger, & Ratner, 1993).

The ever-present difficulties in designing animal experiments such that the animal is motivated to do as the experimenter intends make such analyses difficult with other species – to the extent that Zentall (2006) suggested that, given the number of social and non-social learning factors that need to be distinguished from imitation, inclusion of the recognition of intent might preclude any finding of imitation in non-verbal animals (including young humans).

Instead, Zentall (2006) proposes controlling for a list of pre-identified non-imitative learning behaviors and then, by a process of elimination, calling any learning that still occurs "imitative". Using this looser definition, there are a number of studies that compare how often organisms utilize a particular method to achieve a specific task – having seen conspecifics perform the task in one of the possible ways. Such studies, using budgerigars (Dawson & Foss, 1965), monkeys (Custance, Whiten, & Bard, 1999) and rats as subjects, show that an animal's preferred method of achieving specific aims varies according to how it has seen other animals perform the same task.

This has been demonstrated most clearly in chimpanzees (Buttelmann, Carpenter, Call, & Tomasello, 2007) who operated a device with their foot when an unencumbered human demonstrated its operation in this way but used their hands after seeing a human with his hands full operate the device with his foot. That is, they seem capable of differentiating between cases when the person could and could not use their hands and concluding that, when he could but didn't, there must have been a reason for this.

Once again, we are left with a question to answer: is it more likely, given the evidence we have seen from other species, that so useful a learning mechanism (bridging the gap between instinctive and self-learnt behaviors, as Zentall, 2006, notes) is restricted to a single species or that imitative learning is likely to be a common ability of many social species?

False Belief

Perhaps the best known of the tests for theory of mind are those for false beliefs. That is, whether an organism can predict the actions of another organism based on the differences between their knowledge about a situation. The ability to understand false beliefs has proved very difficult to demonstrate in animals – in part, no doubt because of the required complexity of the task.

The classic design of such tests is to have an animal observe a conspecific observe a reward being hidden and then have the first animal observe the reward being moved while the second is not watching (see, e.g., Call & Tomasello, 1999; Hare, et al., 2000). The behavior of the first animal is then used to attempt to determine whether it realizes that the second animal's belief about the location of the reward is false.

The majority of attempts to test animals understanding of false beliefs, however, have failed. Chimpanzees and other great apes, generally regarded as the most likely of animals to share any particular trait with humans, have not shown an ability to distinguish between ignorance and false belief (Call & Tomasello, 2008). In fact, other than humans aged 5 and over, only dolphins have shown significant evidence of understanding false beliefs (Tschudin, 2006). Thus, false beliefs may mark a qualitative difference between human and (at least the majority of) animal minds. That said, chimpanzees are able to distinguish between another animal's true beliefs and ignorance, indicating some understanding of the complexities of other minds(Call & Tomasello, 2008).

Discussion

There has been a tendency, when considering the results of animal experiments to interpret parsimony as applying to each, new experiment as if it is independent of all other observations. That is, within each experiment, Morgan's Canon is applied and the researchers attempt to explain the results in the simplest psychological terms, without reference to our pre-existing stores of knowledge from previous experiments, related fields, similar organisms and so forth. It is like a physicist who, rather than attempting to create universal laws, attempts to explain the results of each, individual experiment in the simplest terms without reference to the known laws of physics.

Given the research and argument presented above, it seems difficult to conclude that restricting discussion of animal behaviors to 'lower' level psychological process (typically stimulus-reward learning) is an appropriate approach. While an explanation of any behavior can be attempted in stimulus-reward terms, the adequacy of said explanation must be considered. Where such an explanation has to posit the existence of a large number of unobserved learning trials in a variety of different contexts, and alternative explanations exist that accord with our knowledge about the behavior of other species and the relationships between them, a principled application of parsimony would seem to require a reconsideration of Morgan's Canon.

That is, while recognizing the potential dangers of anthropomorphism, it would seem that to adequately explain the findings from a variety of animal studies requires the use of higher-level psychological concepts such as intelligence and an understanding that animals are likely to have at least a limited theory of mind. In short, we need to consider animal behavior from a more cognitive view-point.

Future Research

An acceptance that animal behavior can meaningfully be discussed in similar, cognitive terms to that of humans opens up a range of research opportunities. For example, advancements in genetics and the mapping of the complete genomes of various species allows for the use of synteny homology (the fact that portions of one species genome have corresponding regions on other species genomes where large numbers of genes are found in the same order) would allow the use of analyses to investigate the genetic basis of cognition.

That is, those higher-level psychological processes that have clear equivalents between humans and animals could be isolated using animal genetic models, which have the advantage of large litter sizes and short inter-generational intervals, and then mapped to the human genome. This approach is, in fact, already underway in the medical sciences (see, e.g., Tang, et al., 1999) but its acceptance within psychology has been limited (for exceptions, see Anderson, 1992; Locurto & Scanlon, 1998; Welsh, 2002) with the result that those best suited to isolating and measuring the cognitive traits of animals have yet to start playing a major role.

Conclusions

Morgan's Canon has, over the past century been applied in a manner which, while seeming rigorous, has actually reduced the parsimony of explanations of animal behavior. Moving away from this too-broad application of the Canon, in addition to being necessary in order to develop the best and most parsimonious explanations of animal behavior, will allow animal research to join the cognitive revolution and allow comparative, cognitive research which will shed further light on human cognition.

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