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Animal Cognition: An Aristotelean–Thomistic Perspective

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The relationship between human and non-human animal cognition has been a troublesome one for psychology from the very beginning of the modern era of the discipline. In this paper, we briefly trace the history of thinking on this matter, showing that there have always been difficulties, as mainstream views have tended to extremes, either complete discontinuity (e.g., Descartes) or complete continuity (e.g., Watson). Even in the case of those who push for complete continuity, there have been wildly different interpretations, ranging from extreme anthropomorphizing to extreme examples of treating humans as "just" animals. We present for consideration the Aristotelian–Thomistic approach to this question, and review those areas of research that convincingly demonstrate continuity, and those where the continuity is more questionable. We conclude that the Aristotelean–Thomistic approach provides principled claims of continuity and discontinuity that align nicely with the current research by taking seriously Aristotle's famous definition of the human as a "rational animal," avoiding both the Cartesian separation between rational and animal, as well as the modern attempt to remove the rational from the definition entirely.

Keywords: Aristotle, Aquinas, animal cognition, dualism, functionalism

Philosophers from Plato and Aristotle until Kant and beyond have disagreed about many philosophical questions but all have agreed that humans are rational and animals are not. The distinction perhaps flows most clearly from Aristotle's definition of humans as rational animals, in which he noted that animals and

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humans share sensation, perception, and memory but not intellect. Aquinas and other philosopher–theologians of the middle ages agreed. Descartes took this distinction much further when he famously proclaimed the difference as one of two distinct substances, thus launching the mind–body dispute, still a topic of great concern today. Locke held for the distinction, as did Kant who concluded that animals cannot think about themselves and, therefore, are not rational. It should be noted that one well known modern philosopher, David Hume, dissented and declared that it was simply obvious to him that animals have reason (Hume, 1888/1965, p. 176), based on the fact that animals' actions were adapted to their needs. We might note here that it is not entirely clear that the meaning of "rationality" or "reason" or "intellect" held exactly the same meaning across the enormous span of time separating Aristotle or Thomas Aquinas from Locke, Kant, or Hume, particularly given Descartes' greatly changed idea of the rational as derived from an entirely separate substance; indeed, it is emphatically clear that "reason" in, for example, Hume's explanation of animal reason is not the same as rationality, reason, or intellect for Aristotle.

The shift away from this distinction began in the nineteenth century and, though often now attributed to the work of Darwin, who proclaimed that, "The difference in mind, between man and the higher animals, great as it is, is one of degree and not of kind" (Darwin, 1874, p. 143), the movement toward a belief in a single continuum including humans and other animals was already well established by the time of Darwin's *Origin of Species*. As described by Robinson (1981, pp. 361–363), the notion of the continuum had begun to be articulated in the Enlightenment attacks on Descartes, and the idea of progress had become very widely held, even by people who otherwise agreed on very little. This intellectual environment created a fertile ground for the birth of comparative psychologies. Indeed, Gall had already forcefully stated a biologically-based continuum 50 years before Darwin's *Origin of Species* (Robinson, 1981, p. 362). Interestingly, however, the belief in the continuum has taken very different forms over the last two centuries.

Darwin's contemporary, naturalist George Romanes (1882/1970), held there was a continuity of "the psychological" throughout the animal kingdom, which, in his view, included humans. In some ways (e.g., his focus on observable behavior, his insistence on continuity between human and non-human animals), Romanes sounds like a contemporary comparative psychologist. In other ways, however, Romanes is very different. Importantly, Romanes's continuum between human and non-human animals was constructed with the wholesale importation of (human) mentalistic conceptions applied to non-human animals; in fact, Romanes creates a very anthropomorphic version of the continuum. As Robinson (1981, p. 364) puts it, "Thus, Romanes concludes that ants practice slavery, that the termite queen summons an audience, and that the trap-door spider learns how to prevent illegal entries!"

In the twentieth century, this shift greatly intensified in the disciplines of biology, psychology, anthropology, and philosophy. Psychology, during its lengthy period of behaviorism, tended to view animal behavior and learning as governed solely by the principles of learning and conditioning. Notice the continuum, in this period, is entirely reversed in "direction" compared to that of Romanes, just 50 or so years earlier. Now, under the behaviorist position, there is to be no anthropomorphic importation of human characteristics to the non-human animals. Instead, those principles that account for behavior in the non-human animals are to be extended to account for all human behavior.

However, when human psychology experienced its well-known "cognitive revolution" during the 1970s, animal psychologists quickly began to study animal cognition. Note here that the "direction" of the continuum has once again reversed, now back to extending human characteristics (at least in terms of functional abilities) to non-human animals. Certainly, psychology is now heavily invested in animal cognition at the theoretical and experimental levels. In fact, psychology, as well as the other disciplines noted above, now consider animal cognition to include the following: sensation/perception, learning, categorization, memory, spatial cognition, numerosity, communication, language, social cognition, theory of mind, and metacognition. This list implies no distinction in kind between animal cognition and cognitive processes formerly thought of as unique to human cognition.

The purpose of this essay is fourfold: (a) to propose an Aristotelean–Thomistic (A–T) philosophical model of human and animal cognition which offers solutions to disputed areas, integration of less disputed areas, and constitutes a model able to speak to all the disciplines — biology, psychology, anthropology, and philosophy; (b) to review current claims for animal cognition, particularly the claims made by psychology but also by the other disciplines mentioned above which involve little or low levels of dispute; (c) to examine those claims regarding "higher order" cognition in animals which are hotly disputed; (d) to suggest some respects in which the A–T model provides some advantages over current approaches.

The Aristotelean–Thomistic Philosophical Model

The A–T model has its foundations in Aristotle's general metaphysics, which looks at reality, including cognitive reality, through the lenses of "actuality" and "potentiality." These are basic technical terms of Aristotelian thought, though the idea is really quite simple: reality can be profitably analyzed by looking into how a thing is currently in act, i.e., its actuality, and how it could be in act, i.e., its potentiality. This way of looking at reality implies a tight relationship between a thing's actuality and its potentiality. Thus, different kinds of things are accounted for quite differently because the current actuality of a particular Ficus tree, for instance, will be quite different than other sorts of things (and, by the same

accounting, there will clearly be differences even between different things of the same sort). Moreover, the sorts of acts that a Ficus tree could be doing that it isn't currently doing are often quite different than the sorts of acts that a given human is or could be doing, or, for that matter, that an American Elm tree might do. This sort of analysis of reality as a whole is also directed toward cognition, such that human or animal psychological processes are also accounted for in terms of their current actuality and potentiality. On this notion, for example, external sensation is accounted for primarily as a kind of potentiality to receive information via proper organs, like eyes, ears, etc. When one senses some object in the environment, that potentiality is brought into act: one is actually sensing. There may well be other things (desks, rocks, plants, etc.) in the same environment that do not sense the perceptible object because they do not have that potentiality.

This general metaphysical approach today often goes by the name hylomophism, which comes from the Greek words *hyle* and *morphe*, that is, matter and form, respectively. This introduces two more terms, form and matter, but they serve for our purposes here as correlates to actuality and potentiality, so that in inquiring into a thing's form one is, in a way, inquiring into its actuality; in inquiring into a thing's matter, one is inquiring into its potentiality. A hylomorphic account of reality or of cognition will also include an account of the famous four causes of Aristotle, for these causes are seen to be operative in the genesis of things and because cognition of any kind is itself the result of a causal process that tracks the relationship between an external object and the cognizer. The four causes are the material, formal, efficient, and final. The material cause is that from which something is generated. The formal cause is what makes the thing the sort of thing it is, while the efficient cause bears the closest resemblance to how causation today is often understood in the sciences, because the efficient cause is the primary source of change or rest. The final cause is that for the sake of which the thing is brought about, that is, the goal or aim of a given action or occurrence. Aristotle's own classic example used to illustrate these principles was that of sculpting a statue. The sculptor is the efficient cause. The block of marble is the material cause (the "that out of which"). The image sculpted, Hermes in his example, is the formal cause specifying "what it is." Honoring Hermes is the purpose or final cause.

This brief overview of Aristotelian metaphysics (see Stedman 2013 for more detail) sets the scene for the A–T cognitive model, which is the hylomorphic theory applied to human and animal cognition. Details of the A–T cognitive model have been reviewed in detail in several recent publications (Spalding and Gagné, 2013; Spalding, Stedman, Hancock and Gagné, 2014; Stedman, 2013; Stedman, Kostelecky, Spalding, and Gagné, 2016; Stedman, Spalding, and Gagné, 2016), so only a brief sketch of the overall model will be repeated here. However, we will focus in more detail on how the A–T model treats the external and "internal" senses because these processes overlap with the animal processes of sensation, perception, and memory.

In moving from the metaphysical background to, now, accounting for animal and human cognition on the A–T model, perhaps the most important feature to underscore is the fundamental continuity between humans and non-human animals for most of this process. Indeed, animals (at least so-called higher animals) and humans have the same processes of coming to sense cognition, from initial sensation to the capturing of images to using those images to navigate their environment and everything in between. There is an important and principled difference between humans and animals in cognition, but only at the point of concept production and symbolic manipulation. The continuity between animal and human cognition here is what bears emphasis. Indeed, the A–T account of human cognition is explicitly built off of how animals are seen to cognize and then a difference is introduced only when there seems to be something fundamentally different happening, namely in the production of concepts and the symbolic manipulation of those concepts in various ways.

Cognition in the A–T framework commences with sensory information regarding objects in the environment. Every sensible object is itself a composition of form and matter and the form is communicated to the sense organ through the relevant medium (air, water, whatever) while the matter is left behind. The sense organ is predisposed to receive that form, either visually, orally, olfactorily, etc. The organ thus stands ready to receive this form in a way peculiar to it or, to phrase it differently, each organ is ready to be in-formed by the form of the external object. For instance, if I shut my eyes in a lit room, my eyes have the potentiality to receive the forms (actualities) of external objects in a way that other parts of me do not — and clearly in ways that, for instance, a nearby chair does not. I then open my eyes, and this potentiality to receive external forms is actualized, and I am really sensing the external forms of objects in my environment. The potentiality, sight, is brought into actuality, and I am really seeing. This reception of the forms of external things by organs is exactly the same for humans and non-human animals. The sameness does not stop there. The process continues from these external senses to internal senses, in which cognition of particular objects continues to be fundamentally the same for animals and humans alike.

Cognition is certainly more than reception of information of external objects, on the A–T account or, really, any satisfactory account. Upon initial sense reception of the external object, the A–T approach moves inward, as it were, and proposes four internal senses: the common sense, imagination, memory, and the estimative or cogitative sense. Each of these senses has a causal role to play in accounting for the rich cognitive life of all animals and humans.

To begin, the common sense integrates and distinguishes different acts of sensation. It can discern something seen as white from something green or distinguish in something that is white and sweet and rough (like a white sugar cube) — the color white from the sweet taste from the rough texture. In the both cases, the external senses are not capable of fulfilling these distinguishing roles. They are

capable of sensing in the way that they are disposed to do, and such distinguishing between different sensed colors or disambiguating the sense experience of seeing white from being sweet is accomplished by the common sense, to which these different sensations are referred. This sense is common insofar as it integrates different sensations and is able to distinguish among different external sensations and also insofar as sensation is directed toward this sort of discriminating activity.

The next internal sense is the imagination. Now, this is not the imagination of Romantic, poetic creativity or the sort of imagination that we may want to encourage in children, but a more workmanlike capacity to produce images. A particular sensation of an external object occurs by impacting the proper organ; the imagination (*phantasia* in Greek) produces an image (a *phantasm*). Now, the trouble with the word image in English is that it conjures up a picture, whereas the idea here is that any sensation proceeds inward (or, as we might say, up the CNS) and the externally sensed object is present to the mind. Instead of simply a picture of the thing, this image is also supposed to capture the taste of vinegar, or the sound of a violin. As such, sometimes the transliteration phantasm is used instead of the image, to avoid the overly pictorial connotation of image. The key thing, though, is that the externally sensed object is reproduced internally and formally via a capacity called imagination, the product of which is an image or phantasm. The phantasm is the basic sine qua non of cognition on the Aristotelian model, without which there will be no cognition of any sort.

The phantasm is then stored in the memory (called the storehouse or treasury of forms) and can be recalled as necessary. Again, this capacity to remember is seen in humans and non-human animals alike. I can recall an image of my childhood home or where I left my keys this morning, just as my dog recalls where the food is or what I look like, which allows the dog to recognize me or remember where to find food. This capacity is the ability to recall previously sensed phantasms and animals and humans both use it.

The estimative or cogitative sense is given different names based on whether non-human animals or humans are using this capacity. This is the point where one sees the beginnings of a differentiation between humans and non-human animals in their respective cognitive stories, but even here there is a basic similarity. Regarding animals, when a wolf pursues its prey or the sheep flees its predator, it is via the estimative faculty. This estimative faculty is a deeper level of cognition than mere form reception or image construction or even memory, because this cognition goes well beyond the information contained in collecting sense data alone. It is what allows some animals to cognize what is good/useful or bad for them. Moreover, it allows for something like emotion to accompany the perception of a perceptible object, like horror (as when the sheep sees the wolf), desire (as when the wolf sees the sheep) or a kind of friendship (between sheep, say) or enmity. For instance, the notion horror is not explicitly contained in sense image of the wolf. It is, rather, the sheep's complex cognitive life that allows it to perceive

the wolf, recognize it as bad for the sheep, shirk in horror at the sight of the wolf, and then set about a course of action to avoid what is cognized as bad. The A–T tradition (specifically Aquinas) holds that the estimative power even allows for a kind of prudence to occur in the animal, since prudence is understood as a sort of future planning. On this account, only animals that have a fairly robust capacity of memory make such provision for the future, for futurity and memory are clearly bound up with each other. Not only do some animals engage in a sort of foresightedness through the estimative faculty by which they set about a particular course of action, but it is also through this estimative faculty that the A–T tradition accounts for animal learning.

The correlate sense is called the cogitative sense for humans, and it is that by which humans collate different phantasms and organize them. It is, as it were, thinking through (or cogitating) different particular items held in the mind and, as will become crucial, it prepares the phantasm(s) for abstraction into a universal concept. This cogitation occurs in the brain, or, as Aquinas himself phrased it, in a central cell in the head.

Looking back over this account, clearly there is a fundamental similarity in cognition that attains between human and non-human animals in terms of sense cognition. From the initial sensation all the way through to memory, and even, to a point, to the manipulation of an internally held image, the process is the same. This similarity, however, breaks down once concept formation occurs, a process which the A–T approach does not see happening in non-human animals. The key difference between sensible cognition we have been treating and what occurs in concept formation is a move in going from the particular phantasm (or particular intention as it is sometimes called) to a concept (sometimes called a universal intention) that ranges over many different instances. This leap from the particular to the universal, as seen clearly in the sensation of a triangular thing to understanding the Pythagorean theorem, is a move from a particular, sensed triangle to a universal conception of that thing in terms of the properties of right triangularity. Note here that generalization of a response is not automatically an example of a universal concept, nor is the representation of an average. For example, suppose that one came to represent the average of all the triangles one had ever seen. This average triangle representation would still have a particular shape, a particular size, and so on, even if no specific triangle exactly like it had never been seen. Also, consider the case of the sheep into whose field of vision a wolf enters. The sheep immediately perceives that the wolf is evil for the sheep and then the sheep can make a decision regarding how to proceed. In spite of this rich cognitive experience, the sheep does not reckon from its experience of this evil thing to what it is to be evil, or have an account of evil. Nor does the wolf have an account of the good. For humans, by contrast, this sort of abstractive thought occurs naturally and such universal concepts clearly play an important role in our own cognitive lives.

The whole process of sense cognition is fundamentally receptive: the sense organs and internal powers have the capacity of being informed by the particular objects in the environment. The causal story goes from the external, sensible object to that object being internally represented and that the external object is sufficient to cause the internal representation of the particular. Sensation is, for the most part, in potentiality to the external sensible object. The story changes upon the introduction of the concept, since the particular does not, on this account, seem to be adequate to cause a universal notion/concept. As such, at this point A–T cognitive theory posits something active in the mind itself; the mind is itself an agent causing a concept to occur. This process of going from a particular to a universal by way of the agency of the human mind is called abstraction. Once the universal nature is held in the human mind, the intellectual cognition still needs sensation in order to be able to apply that universal concept back to really existing, tangible objects. This act, sometimes known as the existential judgment, affirms the existence of this particular dog, as in, "The dog [universal] is my dog, Tippy [the existent dog]."

Let us see how this model would apply to a hypothetical example of concept formation in a human. Tommy, age 5, looks at a stimulus picture of a cat. This sensory information is processed by neural structures; and, in the A–T model, produces a phantasm representation of the cat stimulus. At the same time, the memory presents exemplars of cats and dogs at the phantasm level. The intellect, via the process of abstraction, then produces the form common to all cats and dogs, the blueprint or structural model as described by Shields (2003). Tommy then makes a comparative judgment involving this stimulus picture of a cat to the abstracted blueprints of dogs and cats (stored in the passive intellect according to A–T theory). Then he makes an existential judgment: this picture of a cat is like cats, not dogs. Then Tommy makes the full existential judgment to the experimenter: that (the particular stimulus picture) is a cat.

Cognitive Processes Common to Humans and Animals

No philosopher of a realist bent has ever denied that humans and animals share a significant number of the cognitive processes enumerated above, particularly sensation/perception, learning, and memory. Depending on definitions and exact meaning, many philosophers, including those holding for the A–T model, would also agree that humans and animals share spatial cognition, and elements of communication and social cognition.

As noted above, the A–T model begins with sensation, and for Aristotle and Aquinas, sensation is the dividing line between animals and plants (space prevents discussion of disputed points about whether plants sense). Animals, from single cell to humans, take in information from their environments through sensory organs. In more complex animals, these sensory organs become highly

specialized and more tuned to specific environmental input. We now have vast knowledge of the physics, chemistry, and biology involved in sensory message sending and receiving at all levels of the animal world. A–T acknowledges the physics, chemistry, and biological mechanisms as agents of efficient cause but adds a deeper philosophical analysis pointing out that the organ is the material cause capable (in potency) of receiving these inputs which specify the change by formal causality. The final cause or purpose is sensory input.

Your dog has five highly evolved senses and specific receptor systems designed to receive varying types of signals. You come in. All the mechanisms of efficient cause commence. His eye, the material cause, in potency until then, activates and receives the sensory visual form. The purpose is served. He has an activated (in act) image ready to be forwarded up the CNS chain. Of course, the activated eye varies across species, e.g., an eagle's visual acuity vs. that of a human, but the process is the same. Perhaps nothing more needs to be said regarding the external five senses.

Our discussion from this point will be primarily directed toward the cognition of higher order animals; however, all animals possess at least rudimentary elements of the processes and mechanisms to be discussed. It is obvious that all animals and humans do not merely receive raw sensation from the external senses. All of these received stimuli immediately begin their separate pathways through the CNS; but, at some point must themselves become integrated with other incoming sensory data. Aristotle, though of course having no more than observation of behavior, induction, and deduction as tools, postulated the internal sense of imagination to account for storage and memory of external sense images. Later Arab commentators on Aristotle continued to refine these constructs, adding to a total of the five elaborated above, and Aquinas continued that tradition.

The mechanism of integrative action for the A–T system, shared by animals and humans and described above, is the common sense which receives and integrates incoming sense data and is brain based. There is a vast amount of psychological and neuroscience research related to discovering and describing this process, called perceptual binding, in both animals and humans. At the human level, John (2002) has proposed a construct called perceptual frames to explain perceptual binding and this model would hold for higher order animals as well. At the level of neuroscience, there is much research aimed at pinpointing brain structures related to perceptual binding (see Movshon and Wandell, 2004, Chapter III: "Sensory Systems"). As noted above, the psychological mechanisms and neuroscience correlates are accounted for in the A–T system as elements of the common sense; but it should also be noted that the A–T system regards these mechanisms and correlates as attempts to tease out specific aspects of the efficient cause. Their products, for example, the perceptual frame, is a combination of material and formal cause, and their final cause is an accomplishment of perceptual binding.

Much the same holds for the phantasm, which retains the perceptually bound sensations, and the imagination, which combines and reassembles data from the phantasm. These mechanisms were recognized by philosophers from Aristotle to Aquinas as obviously occurring in humans and animals. Neuroscience, in particular, has conducted numerous studies of brain mechanisms related to these phenomena. For example, Recanzone (2004) has summarized human and animal research related to auditory and visual cortical regions interacting with each other to produce several mixed visual and auditory outcomes. The same causal analysis as cited above also applies here.

A mechanism related to common sense, phantasm, and imagination and described rather extensively above is the estimative faculty, which enables humans and animals to gauge whether a sensed object is dangerous or not. Of course, modern psychology, biology, and neuroscience agree, and there is an enormous amount of research related to the psychological and biological processes involved: flight or fight (Cannon, 1932); activation of the amygdala in response to a feared object (LeDoux, 2000); the role of learning related to aversive external stimuli and escape or avoidance responses (Miller, 1948); excessive activation of the bed nucleus of the corpus striatum in anxiety disorders (Haufler, Nagy, and Pare, 2013); and much more. All of this research has occurred at the human and animal level, but in our current inquiry we are focused on the animal level.

That animals respond to danger in the environment and that all of the mechanisms mentioned above are represented in animal cognition, from the simplest level to the primate level, is fully established. In addition, psychology and biology have asked how animals know to avoid predators, and answers have clustered around the usual innate/learned options. Studies point toward the three methods of learning: classical conditioning, operant conditioning, and social learning. For example, Shier and Owings (2007) demonstrated that juvenile prairie dogs learned predator avoidance by observing experienced adult behavior related to predators, an example of social learning. Mitchell, McCormick, Ferrari, and Chivers (2011) showed that damselfish respond with antipredator behavior to a chemical alarm substance released when a predator kills or wounds one of the school. They proposed a combination of innate mechanisms and classical conditioning to explain their finding.

There is certainly no dispute that learning occurs in humans and animals and does so according to the three established methods of learning elaborated above. All occur in humans and animals and all have been studied extensively by biology, psychology, and neuroscience. At the neuroscience level, neuroimaging of humans and animals and pinpoint placement of sensors in animal brains has increased knowledge of brain responses and changes during learning. In both humans and animals there is increased density of synaptic connection during learning (Yang, Pan, and Gan, 2009) and known areas of increased activation during learning (Manns and Squire, 2001).

Three other claims from the animal cognition list include spatial cognition, social cognition, and communication. Animals certainly manifest all three; and, as is true of danger avoidance and learning, all involve memory. However, we stipulate memory's necessity and will discuss memory in more depth later. Animals show spatial cognition in many ways, such as learning where "food patches" are located (Valone, 1989) or following scouts to food sources (von Frisch, Wenner, and Johnson, 1967) or establishing and defending a defined territory (Marchetti, 1993). Most animals also manifest rather elaborate systems involving social cognition. Ants differentiate non-nest mates by chemical discriminative learning (Brandstaetter, Endler, and Kleineidam, 2008). Animals recognize their own kind through combinations of sight, shape, smell, and calls. Chimpanzees form rather complex societies with hierarchical structure (Sakura, 1994). With regard to communication, birds produce songs to mark territory and attract mates (final cause) and these songs vary in urban vs. non-urban environments (Slabbekoorn and den Boer–Visser, 2006). Chimpanzees produce different calls to indicate the presence of and possibly the quality of food (Slocombe and Zuberbuhler, 2006). These examples of animal spatial cognition, social cognition, and communication can be multiplied by the hundreds if not thousands. All these studies demonstrate the existence of spatial cognition, social cognition, and communication and are accounted for in the A–T model by efficient causality and the sensory powers.

Psychology has been particularly interested in memory. Schacter and Tulving (1994) proposed a number of subdivisions of memory as follows: episodic, the long term memory of life events; procedural, the memory of how to do things; semantic, the memory of the meaning of words; priming, an implicit memory effect in which exposure to a stimulus influences response to a later stimulus; associative, memories underlying classical conditioning and fear conditioning; and non-associative, the memories underpinning habituation (decreased response to a stimulus) and sensitization (increased response to a stimulus).

It is obvious that animals possess associative, non-associative, implicit, and priming memory. All of these subtypes are demonstrated in fear conditioning and escape/avoidance training. The training protocol, established by Mowrer (1951), clearly manifests all four and has been replicated across many animal species. Whether animals show episodic and some elements of semantic memory is disputed; however, animal researchers claim that even birds have episodic memory (Lucas, Brodin, de Kort, and Clayton, 2004).

The A–T model can accommodate all these claims, as they all revolve around the kinds of sensory powers that are, in the A–T view, shared by humans and other animals. Thus, although the A–T model might well dispute the underlying metaphysics (i.e., most of the reviewed work at least implicitly makes use of metaphysical positions other than those of the A–T model), the model can accommodate the experimental results.

Disputed Claims for Animal Cognition

Psychology, and the other disciplines mentioned above, sometimes assert that animals also possess these cognitive abilities: categorization, numerosity, language, theory of mind, casual reasoning, and metacognition. Since no animal has an elaborate language system similar to the average human, substantiation of these claims must be made on the basis of experiments and field studies designed to demonstrate each ability. It is also important to define and state the limits of each of the categories mentioned above.

Another important principle to keep in mind is Morgan's Law which states, "In no case is an animal's 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 evaluation and development" (Morgan, 1894, p. 53). In recent times this principle has become known as Morgan's Challenge (Andrews, 2015), a warning against over-interpreting animal behavior as based on the same mechanisms utilized by humans. In other words, this is a warning against interpreting animal behavior from an anthropocentric viewpoint.

Humans think in categories or concepts, and this fact is generally recognized by philosophers and psychologists, although they might disagree on how this mental feat is accomplished. But, do animals have the ability to form such mental categories and, if so, how? One approach to this question is to determine whether primates and lower animals can match animal pairs by category, for example, a bird with a bird, etc. A recent study by Vonk (2013) showed that the apes in her study could categorize types of animals at a better than chance level, and she argued that this finding demonstrated their ability to form concepts. The research method involved food reinforcement when the apes correctly matched pairs on a screen and presentation of a blank screen when the match was incorrect. After hundreds of trials, correct matching was achieved at a better than chance level. Others have demonstrated similar findings with dogs, bears, and pigeons. However, in a direct application of Morgan's Challenge, one could argue that all these studies are examples of discriminative learning; difficult discriminative learning, perhaps, but discriminative learning none the less. Hence, the results can be explained by the processes common to humans and animals covered in the last section (i.e., sensory integration, learning, and memory) and the same A–T four cause analysis would apply.

Numerosity, also known as numerical cognition, studies the cognitive, developmental, and neural bases of numbers and mathematics in humans and animals. These studies tend to be very elaborate, with considerable effort made to control for learning and other variables. In general, animal studies have shown that a variety of animals, including rats, lions, dogs, fish, and primates have "an approximate sense of number" (Dehaene, 1997). Rats can be trained to bar press for food at rates of eight and 16 presses. Later bar pressing

approximates averages of eight and 16; however, actual pressing varies around a normal distribution, thus the label "approximate." One series of studies on human infants found that infants seemed to show approximate number recognition before 6 months of age, but by 6 months could reliably discriminate ratios of 2:1, but not more complex ratios. Researchers argue that before 6 months, humans resemble animals (Feigenson, Dahaene, and Spelke, 2004), but these interpretations are contested along nature/nurture lines (Carey, 2009). Of course, primate studies draw the most attention. Woodruff and Premack (1981) showed that adult chimps correctly performed numerical operations on proportions with a variety of objects after extensive training. Tomonaga (2008), in a complex series of three experiments, found that chimps, trained on a numerosity discrimination task which required them to choose the larger number, found that the chimps could discriminate larger numbers and did so in line with Fechner's Law (accuracy increases linearly with the logarithmic values). He concluded that chimps did use relative numerosity as a discrimination cue.

There is a very large animal literature dedicated to demonstrating numerosity and, no doubt, animals do demonstrate limited numerical abilities. However, as with concept formation, Morgan's Challenge must be noted. Can learning and memory account for these results or is there surplus cognition at work? Perhaps more critically, if these limited numerical abilities can be accounted for via learning and memory, does that show that much less limited numerical abilities can also be accounted for in the same way? Again, even though the A–T model might well dispute the metaphysical implications of various interpretations, the model can accommodate these results, as an application of particular reason (i.e., of reasoning about particulars, but which does not extend to universals).

No one doubts that animals communicate but many doubt that they have language. However, there have been extensive efforts to demonstrate language with apes, dolphins, parrots, and sea lions. Most efforts have occurred with chimpanzees, both those raised in human families (Kellogg and Kellogg, 1933) and those taught in laboratory settings (Savage–Rumbaugh and Rumbaugh, 1998; Terrace, Petitto, Sanders and Bever, 1979). After it was realized that chimpanzees lack the biological apparatus to speak human words, research shifted toward teaching artificial symbolic communication, specifically the American Sign Language (ASL) system. In the most well-known experiment, the Gardeners (Gardner and Gardner, 1978), using well established associative learning methods (shaping, modeling, and molding) trained a chimpanzee, Washoe, to use 132 ASL signs and claimed their findings demonstrated that apes can learn and use language. Terrace, cited above, countered by training a chimpanzee using the Gardeners' methods. He found the chimp, Nim, learned — but Terrence asserted that associative learning could account for the findings with no need to claim comprehension of symbolic language, an example of heeding Morgan's Challenge. Mary George (2003) made a similar point in a rigorous philosophical analysis of Terrace's findings with Nim.

An additional and very significant critic is linguistic Noam Chomsky, who early on pointed out that true language requires certain structural principles, including the ability to produce a potentially infinite number of grammatical strings (Chomsky, 1968). No animals have unambiguously shown that capacity. Hockett (1977) identified seventeen features of human language, including semanticity, discreteness, and arbitrariness, none of which has been unambiguously found in animals. Once again, the A–T model would most likely come down on the side of denying that animals have language. The A–T model would hold for association learning and memory as sufficient mechanisms for the animal behaviors under investigation, as suggested by George (2003).

The notion of "theory of mind," introduced by Premack and Woodruff (1978), is defined as the ability to predict and explain the behavior of another by attributing mental states to the other. In fact, they claimed that a chimpanzee, Sarah, demonstrated this capacity. Sarah was shown videos of humans solving simple problems (reaching for bananas, lighting a heater in a cold room) and then shown photos depicting solutions to these problems. She was able to choose pictures depicting solutions at a greater than chance level, and the investigators interpreted this result as demonstrating that Sarah had known the intentions and beliefs of the human models. Critics pointed out that there were alternate explanations, including that Sarah really attended to the goals of the actors and not their mental states. Later, Premack himself endorsed this interpretation (Premack and Premack, 2003).

Theory of mind is generally accepted as a human capability (indeed, theory of mind is arguably the basis of all human anthropomorphizing!); however, this has not been convincingly demonstrated with primates. Interested philosophers and animal researchers later shifted to the notion of "mind reading" with emphasis placed on primates knowing others' perceptual states. Again, debate is intense regarding the interpretation of the findings. In a review, Call and Tomasello (2008) argue that evidence supports chimpanzees' understanding of others' goals, intentions, and knowledge; Povinelli and Vonk (2004) assert that evidence supports a theory of behavior but not a theory of mind.

As with all disputed capacities mentioned above, Morgan's Challenge needs to be satisfied first. The A–T model would side with Povinelli and Vonk in acknowledging a theory of behavior, based on memory and associative learning, particularly social/observational learning. At the philosophical level, the A–T model would argue that abstract concepts are necessary for development of a real theory of mind and that only humans are capable of that level of abstraction.

Metacognition refers to the capacity to monitor one's cognitive processes, the ability to act to control those processes, and knowledge of how one's cognitive processes function (Flavell, 1979). Intact humans demonstrate all these elements and can describe them with linguistic report. Since animals cannot use language to consciously report their mental states, researchers have designed complex and

ingenious non-verbal experiments to attempt demonstrations of metacognition. A recent study evaluating seven hypotheses for metamemory performance in rhesus monkeys (Basile, Schroeder, Brown, Templer, and Hampton, 2015) is an excellent example. These investigators tested seven possible mechanisms to account for "information seeking" by the monkeys and eliminated six (behavioral cue association, rote response learning, expectancy violation, response competition, generalized search strategy, and postural orientation) but found evidence for memory monitoring, which they interpret as an indicator "that rhesus monkeys can use memory strength as a discriminative cue for information seeking, consistent with introspective monitoring of explicit memory" (p. 85). In their discussion, they acknowledge that there is a major controversy in the field of non-human metacognition regarding whether findings can be explained using associationist paradigms or whether findings require cognitive states not usually attributed to non-humans.

This study is a good example of the strength of the A–T model in that it is an attempt to sort out mechanisms (efficient causes); but, as the authors point out, the study raises issues at the philosophical level, such as whether animals have subjective experience, whether animals have mental states that are equivalent but more limited than humans, and so forth. The A–T model can accommodate the research into mechanisms while at the same time offering a philosophical level of analysis relevant to the metaphysical issues cited above. In the case of metamemory, the A–T model may well be in line with the researchers' conclusions that rhesus monkeys can monitor their memories about "particular" objects in a way similar to humans because the A–T model acknowledges that animals have powerful memory systems for the particular (vs. the abstract). In other words, animals can remember and track memories for where things are, how to follow cues from one place to another, but cannot remember (the meaning of) mathematical formulas.

Advantages of the A–T approach

Throughout this essay, we have suggested that the A–T approach has advantages as an underlying philosophy of science for psychology, including comparative psychology or animal cognition. In this section, we wish to describe explicitly some of these advantages.

The brief history of comparative psychology and overview of animal cognition that we have provided indicates some of the difficulties involved in determining whether there is, or is not, a single psychological "continuum." However, there are difficulties avoiding anthropomorphizing. There are difficulties in downplaying human characteristics as being "just" an extension of some other non-human capacity. For example, when categorization is described as "just" discrimination, it hides from view the fact that, for humans, the ability to discriminate among

particular objects is just one aspect of categorization. This "just" discrimination view would lose the other aspects of human categorization (e.g., the ability to use the category symbolically in reasoning and inference). There are difficulties of interpretation (e.g., when an animal is extensively trained and is able to perform a particular behavior taken to be indicative of some human-like capacity). We might note in this respect that there is a severe asymmetry in the famous Morgan's Challenge, namely, although it is right to say that we should avoid proposing a "higher" explanation of an animal's behavior if a "lower" explanation is available (setting aside, of course, the fact that "higher" and "lower" here are deeply infected with a belief that there is some scale on which the human is higher!), there should be a corollary, such that we must not conclude that a given human behavior is explained in the same way as a superficially similar behavior in another animal can be explained, until such an explanation is actually demonstrated. That is, although we use "lower order" mechanisms to explain behavior, and only posit "higher order" explanations when needed, we cannot simply assume that a given human behavior is actually explained by a lower order process, until it is shown, in detail, how the lower order process actually accounts for the human behavior. To be fair, the early behaviorists, at least, attempted and expected such demonstrations. Consistent with their understanding of the "directionality" of the continuum between non-human and human, they attempted to directly apply the "laws of learning" to many forms of human behavior, and it was precisely the failures of many such demonstrations that led towards the cognitive revolution in human psychology (see, e.g., Robinson, 1981, pp. 421–422 and 445–453). Thus, for example, we might be willing to account for basic numerosity in both humans and non-humans as arising from the same processes. This does not mean, however, that those same processes extend to the explanation of aspects of human numerosity beyond the basic, let alone, say, the human ability to use the calculus, or any other modern mathematical system, until it can be shown that these are actually explained by those same processes.

Perhaps most importantly there is a difficulty in that there is no explicit or clear criterion for what constitutes continuity vs. discontinuity. Consider again Darwin's (1874, p. 143) famous quote: "The difference in mind, between man and the higher animals, great as it is, in one of degree and not of kind." What, exactly, does this mean? Is not speciation itself indicative of a difference of "kind"? Do, say, the minds of goats and bacteria, differ only in degree? What about goats and ravens? If not, why is the difference of degree limited to higher animals vs. humans, with the other differences on the scale being differences of kind? Why is "mind" the only thing that seems to be treated in this kind vs. degree way? Is not flying a different kind of locomotion than walking, despite the underlying similarities of mechanical structure or the underlying similarity of being an adaptation to the need for locomotion? What, precisely, indicates a difference of kind, rather than of degree?

Ultimately, whether one holds for a "continuum" or not appears mostly to depend on underlying metaphysical commitments, rather than on observation or

experiment. If you hold a metaphysical position that implies a continuum, you see continuity, if not, you see discontinuity. It is important to note that this is historically true — the philosophes of the Enlightenment did not attack the Cartesian separation of man and animal due to new scientific discoveries showing continuity, but because of their metaphysical commitments. The notion of "progress" that played such a large role in the intellectual changes of the Enlightenment, and even in the acceptance of Darwinian evolution, was not discovered by science. If one's views are conditioned by one's metaphysical positions, one needs to pay special attention to one's metaphysics. Explicitly considering the A–T view provides a clear linkage, as we showed in a previous section, from deep metaphysical principles all the way up to human cognition.

As we have described, the A–T view makes clear claims about what sorts of things should be fully continuous (all the fully sensory powers), and what should show some discontinuity (only those things that are at least in part driven by the intellectual powers). We also note that the basic metaphysical structure (form and matter) is the same for human and non-human animal. It is also, perhaps, important to recognize that the A–T view would also expect various kinds of continuity and discontinuity among different non-human animal species, depending on their own particular sets of powers and abilities. This way of considering the A–T view shows a strong expectation of continuity, but also of limited and specific discontinuity, between human and particular non-human animals. It also inhibits anthropomorphizing, because the focus is on the underlying powers and not the specific forms of behavior, such that superficially similar behavior need not be explained in the same way. It also inhibits the downplaying of the specifically human characteristics, again because the focus is on the underlying powers that are commonly demonstrated across many particular human behaviors. We might also note here that exactly the same kind of A–T argument for principled continuity and discontinuity among humans and non-human animals can be applied with respect to the emotions, as was recently done by Cates (2009).

Although here we are focusing somewhat on the difference between the human and the non-human, it should be clear from our presentation of the A–T view that the extent to which the A–T view suggests discontinuity is actually much smaller than most people might think. Although the distinction between the human and the non-human is important in the work of Aristotle and Thomas, that distinction arises within a context of deep similarity and continuity. It is a serious misreading of both Aristotle and Thomas to focus solely on the "rational" part of the "rational animal" if one wishes to understand the human in its totality. Indeed, the separation of "rational" from "animal" is precisely the Cartesian mistake, and has no place in the A–T view. In the A–T view, there is one, unified, human that is both rational and animal. Philosophically, the A–T model holds that each existing human (or animal, for that matter) is one substance with varying powers or faculties. These powers or faculties are entirely brain-based for animals but not so

for humans: human substance also includes the intellect and will. Some philosophers refer to this as a moderate dualism. Whatever one calls it, it clearly avoids the radical differentiation of substance found in the Cartesian formulation (see Stedman, Spalding, and Gagné, 2016, p. 27 for further discussion).

We must also emphasize that, although the A–T view identifies various sensory and intellectual powers, it is unlike the Cartesian approach in that the intellectual operations are deeply dependent on the operation of the sensory powers. Both Aristotle and Thomas discuss at quite some length the extent to which the proper operation of the intellectual powers depend upon the sensory powers, for example, in the dictum that there is no thinking without phantasms, or that there is nothing in the intellect that was not first in the senses. These are not claims that the intellect simply duplicates the sensory powers, but rather that the intellect operates upon the products of the sensory powers. This also means that the normal operations of the intellect are, in this sense, dependent on the normal operation of the brain as the home of the sensory powers, and in addition that at least some operations that look similar to the normal operations of the intellect will be seen in non-human animals (due to the shared sensory powers and the shared brain structure), particularly if they are seen in rudimentary forms in the non-human animals.

At this point we need to consider the A–T model's primary competitor as a philosophy of science for animal cognition, functionalism. In fact, functionalism appears to be the reigning philosophy of science for psychology and other disciplines interested in animal cognition. Historically, it should be noted that functionalism emerged as a philosophy of mind (i.e., of the human mind) but has been be applied widely in psychology (Stedman, Spalding, and Gagné, 2016), biology (Lambert and Hughes, 1988), and anthropology (Malinowski, 1960). In its broader application, functionalism asserts that mental and all other psychological or biological states are constituted by their functional role in a system. In practical terms for our purposes, the model proceeds as follows: external stimuli interact with the external senses and internal processes (many of which are constructs) and produce observable behavior. Critically, the internal processes are constituted by their functional roles, not simply described by them. Thus, the extent to which there is continuity or discontinuity depends on the extent to which the functional roles are the same within the particular cognitive systems. Again, the very same problems that we mention above in terms of establishing continuity or discontinuity arise. In particular, it is difficult to say whether the functional role is the same without understanding exactly how cognition works in a particular case. Is flying really the same as walking, because both fulfill the functional roles of locomotion? If the functional roles are merely similar, is that a distinction of degree or of kind? It should also be noted that the application of functionalism to animal cognition deals primarily with understanding the mechanisms of efficient causality and then claims to be a full ontological explanation

of reality. From its outset, functionalism has been severely critiqued within philosophy as trivial (Godfrey–Smith, 2008), as having problems in accounting for casual effects of mental states (Kim, 1989) and as having failed in the task of theory building in psychology (Stedman, Spalding, and Gagné, 2016), and so on. We assert that the A–T model accounts for all that is claimed for functionalism and then accounts for animal and human cognition at a deeper ontological level (see Stedman, Spalding, and Gagné, 2016, for a full discussion).

Finally, although not the focus of this essay, we note that belief in a pure continuum from the non-human to the human has consequences far beyond comparative psychology or animal cognition. For one thing, the "direction" of the continuum, vacillating between anthropomorphizing animals vs. reducing humans to "just" animals as we described earlier, is entirely replicated in considering, for example, ethics. There are many current claims that because humans are just animals, non-human animals also have rights exactly as persons. Rather ironically, this view would invalidate the ethics of research involving non-human animals, as they do not give informed consent for participation. It is easy to see the essential instability of this position, which generally collapses into claiming rights for non-human animals, while simultaneously maintaining claims of uniquely human responsibilities towards those animals. Of course, it is just as consistent to reverse the direction and say that humans can (and should) be treated in the same way that we have previously treated animals, NOT as persons, but simply as tools for our own purposes. So, we re-iterate one of our primary points: adopting a particular view on the continuum is often a matter of metaphysics and rarely a matter of science, but metaphysical commitments flow through to all kinds of interesting conclusions, including those beyond the scientific issues. Best, then, to pay attention to the metaphysical commitments.

Conclusions

The A–T model can be conceived, as we have argued earlier (Stedman, Kostelecky, Spalding, and Gagné, 2016), as a philosophy of science for psychology and, in this case, as a philosophy of science for animal cognition. As we have demonstrated, although ancient in origin, this formulation of classical realism is quite parallel to modern psychology and neuroscience (Stedman, 2013) and offers a deeper philosophical perspective for both the processes common to humans and animals and those claimed for animals but intensely disputed. The A–T model is particularly valuable in its application of Aristotle's hylomorphic theory to questions of animal cognition. As pointed out throughout this essay, all research into mechanisms falls under the efficient cause and, thus, the A–T view can accommodate all the empirical findings. Analysis according to material and formal causes adds philosophical depth, is compatible with the common human–animal processes, and can provide depth to discussions of the disputed processes.

Analysis according to the final cause simply points out that all processes have a purpose, individually or in interaction with other processes, within the biological system of the particular animal under consideration (whether human or non-human). Finally, we have attempted to show that the A–T view, far from being outmoded, provides insight into the nature of the continuum from the non-human to the human.

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