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Review

The mind behind anthropomorphic thinking: attribution of mental states to other species

Esmeralda G. Urquiza-Haas^{a, b, *}, Kurt Kotrschal^a^a Department of Behavioral Biology, University of Vienna, Vienna, Austria^b Department of Cognitive Biology, University of Vienna, Vienna, Austria

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Humans readily attribute intentionality and mental states to living and nonliving entities, a phenomenon known as anthropomorphism. Recent efforts to understand the driving forces behind anthropomorphism have focused on its motivational underpinnings. By contrast, the underlying cognitive and neuropsychological processes have not been considered in detail so far. The marked increase in interest in anthropomorphism and its consequences for animal welfare, conservation and even as a potential constraint in animal behaviour research call for an integrative review. We identify a set of potential cognitive mechanisms underlying the attribution of mental states to nonhuman animals using a dual process framework. We propose that mental state attributions are supported by processes evolved in the social domain, such as motor matching mechanisms and empathy, as well as by domain-general mechanisms such as inductive and causal reasoning. We conclude that the activation of these domain-specific and domain-general mechanisms depend on the type of information available to the observer, and suggest a series of hypotheses for testing the proposed model.

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It may be considered a human universal to anthropomorphize the relevant subjects and objects in one's environment. Anthropomorphism is defined as the attribution of human characteristics or behaviour to any other nonhuman entity in the environment and includes phenomena as diverse as attributing thoughts and emotions to both domestic and wild animals, to dressing a Chihuahua dog as a baby, or interpreting deities as human. Several authors have addressed the multifaceted nature of anthropomorphism (Kracher, 2002). Fisher (1991) identified two different ways in which people engage in anthropomorphic thinking. He defined 'interpretative' anthropomorphism as the attribution of intentions, beliefs and emotions to nonhuman agents based on their behaviour and 'imaginative' anthropomorphism as the representation of imaginary and fictional characters as human-like. Representing gods as human-like or as having human-like characteristics such as personalities, emotions and interests is an example of what Fischer (1991) defined as imaginative anthropomorphism. Inferring that our cat is hungry because it sits in front of the fridge and meows or that a dog is soliciting play when it barks at us are

instances of interpretative anthropomorphism. In this review, we focus mainly on interpretative anthropomorphism, that is, in the attribution of mental states to other animals. Mental states are understood here as brain events that are causally linked to observed behaviour.

Animals are by far the most frequent nonhuman targets of people's attribution of mental states, perhaps because humans seem to be biophilic, that is, instinctively and intensely interested in nature and animals (Wilson, 1984). Babies pay more attention to animals than to any other kind of object in their environment (DeLoache, Pickard, & LoBue, 2011). Even 2-day-old babies prefer to look at point light displays of biological motion to other kinds of motion (Simion, Regolin, & Bulf, 2008). In addition, the first words children produce are nouns, including proper names and common names of small objects, food items and animals (Nelson, 1973). Caselli et al. (1995) using parental report data of 659 English and 195 Italian infants between 8 and 16 months of age found that animal names and sound effects of animals (woof, meow, quack, moo, etc.) were among the first 50 words produced by infants. The younger the children, the more this is the case and the greater also their interest in animals (Wedl & Kotrschal, 2009). Even among adults, living beings engage the attention of people more than objects do (New, Cosmides, & Tooby, 2007). The evolutionary logic behind this is that paying selective attention to

* Correspondence: E. G. Urquiza-Haas, Department of Cognitive Biology, University of Vienna, UZA 1 Biologiezentrum, Althanstraße 14, 1090 Vienna, Austria.

E-mail address: esmeralda.urquiza@univie.ac.at (E. G. Urquiza-Haas).

other living beings is relevant for individual fitness (Barrett, 2005; Barrett, Todd, Miller, & Blythe, 2005). Conspecifics and heterospecifics are, after all, among the strongest agents of selection for living beings (Dawkins & Krebs, 1979).

Many consequences of anthropomorphism are known. For example, people are more willing to pay for the conservation of animals than plants and more for vertebrates than for invertebrates, regardless of the roles of these organisms in ecosystem functioning or of their taxonomic uniqueness (Martín-López, Montes, & Benayas, 2007). A similar tendency holds even for governmental decision making: species that are phylogenetically closer to humans or are similar in appearance to humans receive a higher share of conservation funds and policy attention (Martín-Forés, Martín-López, & Montes, 2013). The closer the morphological and behavioural resemblance of animals to humans, the more people tend to project human characteristics and, more specifically, human mental states on them (Driscoll, 1995; Eddy, Gallup, & Povinelli, 1993; Harrison & Hall, 2010; Herzog & Galvin, 1997; Nakajima, Arimitsu, & Lattal, 2002). Perceiving or inferring that other living beings have certain mental states such as emotions or awareness also has important consequences for their moral status (Gray, Gray, & Wegner, 2007). Gray et al. (2007) found that living beings that are thought to experience emotions, including the capacity to feel pleasure and pain, are more likely to be attributed with moral rights. In particular, beings that are considered intelligent and aware are held responsible for their actions (Gray et al., 2007). Linking worthiness of protection with anthropomorphic features is even common in the field of animal ethics (Singer, 1975; Würbel, 2009).

The debate about the nature and implications of anthropomorphism has rarely been neutral or scientifically objective but has focused mainly on its fallacious essence (e.g. Kennedy, 1992), which has diverted attention away from the goal of understanding the nature of the phenomenon. The term itself is not clearly defined and can have multiple meanings and, most importantly, multiple implications. For example, by labelling the attribution of jealousy to our dog as anthropomorphic, does this mean that dogs are not capable of feeling jealous because jealousy is an emotion that only humans can feel, or that we cannot establish with objectivity what our dog is experiencing because humans and dogs have a completely different 'Innenwelt' and 'Umwelt' (von Uexküll, 1909). Both are historical theoretical positions that have long been at the centre of the debate about anthropomorphism, but will not be addressed here. Recent results on dog inequity aversion (Range, Horn, Viranyi, & Huber, 2009) and on the general homologies in the social brains of mammals and other vertebrates (Goodson, 2005) hint at the possibility that much of what has been considered as anthropomorphic interpretations may in fact do more justice to the mental states of other animals than was previously believed. In the present review, we focus on anthropomorphism as the result of a set of cognitive processes, but we do not make any assumption regarding the uniqueness or accuracy of these attributions.

WHY ANTHROPOMORPHIZE? CURRENT HYPOTHESES

Several hypotheses about the nature of anthropomorphism have been proposed. Some of these try to explain anthropomorphism in general, while others are particularly aimed at mind attribution to other species. Based on the archaeological evidence that marks the transition between the Middle and the Upper Palaeolithic some 60 000 years ago, Mithen (1996) proposed that the structure of the human brain underwent a reorganization that involved the connection of previously separated and specialized mental modules. According to this hypothesis, anthropomorphism resulted

from the 'talk' between a putative social intelligence module, specialized in dealing with the complexity of social interactions, and a natural history module, processing information related to the biological domain. Even though according to this hypothesis, anthropomorphism initially arose as an emergent property, it soon became relevant to human fitness as it potentially increased hunting success and eventually set the stage for animal domestication (Mithen, 1996).

Anthropomorphism has also been proposed to be a result of a cognitive default state. The main idea behind this hypothesis is that the human brain evolved to efficiently process social information. Within this framework, anthropomorphism emerges as an automatic response to any human-like behaviour (Caporael & Heyes, 1997) or human-like feature (Guthrie, 1997) that requires a swift identification or interpretation, which cannot be accounted for using the knowledge at hand. The cognitive default hypothesis proposed by Caporael and Heyes (1997), which is similar to Dennett's 'intentional stance', is based on an underlying assumption that every behaviour is produced by internal mental states (Dennett, 1971). According to these hypotheses, this human-centred intentional stance is gradually restrained as soon as alternative explanations or suitable terms to explain or describe the behaviour of another nonhuman entity become available (Caporael & Heyes, 1997). Slightly different in its core assumptions, the 'cognitive default' proposed by Guthrie (1997) is portrayed as a host of mechanisms evolved to interpret any ambiguous stimulus in the environment as human-like or human-related.

Caporael and Heyes (1997) also discussed the possibility that at least some mental state attribution to other species might be a result of interspecific behaviour recognition. Humans share a series of behaviour patterns and social brain and physiological mechanisms with other species (e.g. Goodson, 2005), which evolved through either common descent or convergent evolution, and this may potentially allow for a certain interspecific understanding (Caporael & Heyes, 1997; Julius, Beetz, Kotrschal, Turner, & Uvnäs-Moberg, 2012). Based on this hypothesis, anthropomorphism is not entirely arbitrary, since the attribution of mental states is partially rooted in common mental and behavioural substrates in humans and other animals.

A recent theoretical model of anthropomorphism developed by Epley, Waytz, and Cacioppo (2007) proposes that anthropomorphizing has strong motivational triggers, particularly effectance and sociality. The first is described as the need to make sense of the actions of other agents to reduce uncertainty concerning their behaviour, and the second refers to the need of people to maintain social connections. It is therefore expected to find an increased tendency to anthropomorphize in situations of high cognitive load (e.g. situations in which a lot of information needs to be processed at the same time) and in social isolation (Waytz, Gray, Epley, & Wegner, 2010).

One of the main shortcomings of previous hypotheses is their lack of focus on the proximate mechanisms triggering anthropomorphism. Even though many authors have already proposed that mind attribution is based on the same processes engaged in social cognition (Epley et al., 2007; Kwan, Gosling, & John, 2008; Waytz et al., 2010), only a few systematic studies have identified the specific processes, triggers and factors influencing these attributions (Barrett, 2005).

Our aim in the present paper is to review the available evidence concerning the cognitive processes involved in the attribution of mind to nonhuman animals, and to propose a framework that integrates the functional and mechanistic aspects of anthropomorphism. Based on this review we discuss previous models in the light of the proposed framework and discuss some of the potential implications and predictions derived from it.

ATTRIBUTION OF MENTAL STATES TO ANIMALS: PROCESSES INVOLVED

Mental representations such as those involved in anthropomorphism probably show a cognitive dynamic conforming to the 'iterative reprocessing model' (Cunningham & Zelazo, 2007) in which mental representations or evaluations are generated through a continuous and iterative processing by limbic and cortical brain structures. According to this model, implicit cognitive mechanisms are responsible for the emergence of early evaluations, whereas representations that are more detailed emerge later as a result of the involvement of reflective processes. Reflective or explicit cognitive mechanisms are considered to be domain-general mechanisms that are subject to conscious control, are effortful, are slower than automatic processes, are limited by working memory capacity, and appear late in ontogeny and evolution (Evans, 2008). Implicit cognitive mechanisms are regarded as automatic, fast and effortless, not subject to conscious control and specialized in certain information domains. Evidence suggests that they appeared early in human ontogeny and evolved early in the brain (Evans, 2008). Our review is organized according to this distinction, beginning with implicit processes.

Implicit Processes

Agency detection and social cognition

Recent imaging studies support the long-standing belief about how the brain deals with different aspects of the world, i.e. that there is a neural distinction in the processing of the physical and social aspects of the world, commonly labelled as 'physical' and 'social' cognition. For example, the processing of objects and subjects is segregated in the visual ventral pathway (Caramazza & Mahon, 2003; Caramazza & Shelton, 1998; Chao, Haxby, & Martin, 1999; Mahon, Anzellotti, Schwarzbach, Zampini, & Caramazza, 2009; Martin, 2007), and there is evidence for two differentiated and extended systems that are specialized in each of these domains (Jack et al., 2013; Martin & Weisberg, 2003). These two networks maintain connectivity during the resting state (Simmons & Martin, 2012) and are mutually suppressed when either of them is active (Jack et al., 2013). The social network in the brain consists of a series of interconnected areas including the superior temporal sulcus, lateral fusiform gyrus, medial prefrontal cortex, posterior cingulate, insula and amygdala, and shows activity overlap with the so-called default mode network (DMN; Goodson, 2005; Mars et al., 2012). This has led some authors to propose that social cognition is the default mode or baseline state of thought (Iacoboni et al., 2004; Jack et al., 2013; Tavares, Lawrence, & Barnard, 2008).

The social network can be triggered in a bottom-up or a top-down fashion, both involving the activation of the posterior superior temporal sulcus (pSTS; Wheatley, Milleville, & Martin, 2007). The pSTS has been described as a 'social-information processing' centre (Watson, Latinus, Charest, Crabbe, & Belin, 2014), and as 'the hub for the distributed brain network for social perception' since it is functionally connected to a host of brain circuits that process specific social information (Lahnakoski et al., 2012). The pSTS is highly sensitive to biological motion, human body motion, hand and mouth movement and facial expressions, as revealed by using either point-light displays or natural biological stimuli (for a review see Allison, Puce, & McCarthy, 2000; Giese & Poggio, 2003; Vaina, Solomon, Chowdhury, Sinha, & Belliveau, 2001).

Entities that induce the activation of the pSTS apart from other humans include animals (Chao et al., 1999; Kaiser, Shiffrar, & Pelphrey, 2012), robotic faces producing emotional expressions (Gobbini et al., 2011), animate-like entities with perceived goals such as robots (Shultz, Lee, Pelphrey, & McCarthy, 2011), or even

animated geometric shapes (Blakemore et al., 2003; Castelli, Happe, Frith, & Frith, 2000; Gao, Newman, & Scholl, 2009; Osaka, Ikeda, & Osaka, 2012; Schultz, Friston, O'Doherty, Wolpert, & Frith, 2005).

Any stimuli indicating animacy will automatically activate the pSTS. However, pSTS activity can also be induced by biasing participants towards looking for intentional motion in randomly moving dots (Lee, Gao, & McCarthy, 2012), for example by asking people to look for eyes instead of a car in ambiguous visual stimuli (Kingstone, Tipper, Ristic, & Ngan, 2004), or by making participants believe that they are playing with a person instead of a computer (Rilling, Sanfey, Aronson, Nystrom, & Cohen, 2004). It can also be activated by instructing participants to predict the movement of two interactive dots (Schultz, Imamizu, Kawato, & Firth, 2004), or by cueing individuals to focus on the social interaction depicted by the movement of two dots rather than on their kinematic properties (Tavares et al., 2008). In fact, it has been shown that biasing people towards perceiving a moving stimulus as animate increases activity in the entire social network of the brain (i.e. superior temporal sulcus, lateral fusiform gyrus, medial prefrontal cortex, posterior cingulate, insula and amygdala), suggesting that perceiving animacy prepares the brain network to process social information (Wheatley et al., 2007).

Motor matching mechanisms

Early theories of social cognition focused on two different ways in which people were thought to gain access to the internal states of others: either by building a cognitive theory about why and how mental states arise, or by using one's own mind to simulate the mind of others (Goldman, 2006). The second hypothesis received strong support by the discovery of the so-called 'mirror neurons' (MN; di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992). MN were found to fire when a monkey performed a certain action, but also when it saw an experimenter perform the same action. Hence, MNs were defined as a cortical system that matches observation and execution of motor actions (Gallese & Goldman, 1998) in animals, including humans (Mukamel, Ekstrom, Kaplan, Iacoboni, & Fried, 2010). The MN system is regarded as the neuronal hardware for motor imitation, but also for synchronizing behaviours and emotions within groups (Rizzolatti & Fabbri-Destro, 2008).

However, can people employ this automatic and embodied process when dealing with other species? It seems that they do so, not only with other animals (Buccino et al., 2004) but also with robots (Gazzola, Rizzolatti, Wicker, & Keysers, 2007; Kupferberg et al., 2012). The generality of this process indicates that the MN system may be less dependent on species-specific shape features than on general motor properties of subjects, animated such as in animals, or evoking the impression of animacy, such as in robots. Results of a functional magnetic resonance imaging (fMRI) study showed that when people observed motor actions of humans (talking, reading and biting), monkeys (lip smacking and biting) or dogs (barking and biting), the difference in activation of the motor and visual areas depended not on the species but on the actions shown (Buccino et al., 2004). Actions that are part of the observer's motor repertoire (talking, reading and biting) are processed by their motor system, including MN, while actions that are not in the observer's repertoire (lip smacking and barking) are processed based only on their visual properties.

The anatomical configuration of nonhuman animals could also be of great importance for the involvement of motor matching mechanisms as triggers of mental state attribution. Kupferberg et al. (2012) asked participants in their study to perform a horizontal or vertical arm movement while watching another person or robot (humanoid robot and a robot arm with and without a human-like joint configuration) performing a congruent or incongruent

arm motion. They found that the movement of the robot arm induced motor interference, which is an increase in movement variance resulting from a mismatch between an intended and observed action, only when it had a human-like joint configuration.

Empathy for pain

Disregarding the heterogeneous history of the concept of empathy, it is generally accepted that it refers to the ability of people to recognize, understand and share other people's feelings (Preston & de Waal, 2002). Studies assessing human empathy towards other species have found that physiological arousal triggered by apparent animal suffering are greatly affected by the phylogenetic distance between animals and humans (Westbury & Neumann, 2008). fMRI studies have confirmed that people engage the same brain areas when observing animal distress as when observing human distress (Filippi et al., 2010; Franklin et al., 2013). Filippi et al. (2010) compared the brain response of vegetarians, vegans and omnivores when observing negative scenes involving either animals or humans and found that vegetarians show a higher engagement of empathy-related areas (anterior cingulate cortex and inferior frontal gyrus) than omnivores. Using a similar paradigm, Franklin et al. (2013) found some overlapping areas that were active when people were observing animal and human suffering, including the anterior cingulate cortex and the anterior insula. A comparison between the two conditions (dog suffering versus human suffering) still revealed some differences. Human suffering showed a stronger involvement of the medial prefrontal cortex (among other brain regions), which is associated with cognitive empathy and theory of mind (ToM), while observing animal suffering elicited a greater response of the inferior frontal gyrus (IFG) and the anterior insula (Franklin et al., 2013). This suggests that animal suffering elicited a greater emotional response than human suffering, while the enhanced activity in the IFG indicates a higher allocation of attention (Franklin et al., 2013).

Evolved schemata and mental representations

Evolved schemata or evolved mental representations may be conceptualized as perceptual, motivational, learning or processing biases. The notion of genetically determined or species-specific learning biases was first proposed by Lorenz (1965; the 'innate schoolmarm' concept), and developed further by Gould and Marler (1987; 'instinct to learn') in response to the behaviouristic perspective of animal behaviour. The main idea conveyed by these concepts is that depending on evolutionary history, different species will still have different learning biases, despite similar or even identical learning mechanisms, pointing at heritable components of mental representations. Based on comparative studies, Gould and Marler (1987) collected ample evidence for this. For example, newly hatched greylag, *Anser anser*, goslings pay keen attention to their parents' beaks, producing the kind of local enhancement that facilitates learning about food (Fritz, Bisenberger, & Kotrschal, 2000).

Humans use motion as a cue for intention and emotion attribution (for a review, see Scholl & Tremoulet, 2000), which has led some authors to suggest the presence of a bias for the representation of recurring patterns of interactions over their evolutionary history (Barrett, 2005; Barrett et al., 2005; Blythe, Todd, & Miller, 1999). According to these authors, being able to discern an aggressive from a playful interaction had important fitness consequences, which created a selection pressure for such a learning bias (i.e. one that enabled individuals to recognize these interactions from motion cues alone). It has been demonstrated by using simple dot animations that people accurately represent and identify animated interactions (including chasing, playing and fighting, among others; Blythe et al., 1999). This ability is independent of cultural background, and improves with age (Barrett et al., 2005).

Similar biases are proposed for the representation of emotional expressions (Leppänen & Nelson, 2009). Humans convey emotional states not only through facial expressions but also through vocalizations as well as body motion, and consistently interpret emotions of moving agents (Atkinson, Dittrich, Gemmell, & Young, 2004; Crane & Gross, 2007; Karg, Kühnlenz, & Buss, 2010), independent of shape (McDonnell, Jörg, McHugh, Newell, & O'Sullivan, 2009). The principles of the expression of emotions are identical between species (Darwin, 1872) while the form is, of course, species-specific (Tinbergen, 1963). This connects to our conclusions about the MN system (above) and raises the possibility that nonhuman animal behaviour is perceived and interpreted via the same mechanisms that evolved mainly for within-species social communication. In other words, if the behaviours displayed by animals contain similar kinematic parameters as would be the case in the human expression of emotion, then the same attribution of emotion will be made. We suggest that this may particularly apply to a limited set of basic emotions shared by humans and animals (Damasio, 1994; Panksepp & Biven, 2012). If the recognition or attribution of such basic emotions is indeed defined by a set of kinematic parameters, this would also explain why primary emotions are more readily attributed to other animals than more complex emotions (Morris, Doe, & Godsell, 2008), or any other kind of mental states (Gray et al., 2007) that may be specifically human.

In conclusion, it seems that the attribution of a specific state (wants, beliefs, emotions) to another being can be substantially supported through automatic processes. In the following, we intend to integrate mechanisms which involve voluntary control and, to some extent, 'higher' cognitive processes.

Reflective Processes

Inductive reasoning

Inductive or inferential reasoning has been traditionally implied in the attribution of mental states to others, including other species (Epley et al., 2007; Kwan et al., 2008). Inductive reasoning is regarded as the process whereby knowledge is transferred from known subjects/objects to novel or unknown ones (Heit, 2000). Induction can be achieved by inferring that *x'* has the same property as *x* because they belong to the same category of objects or beings, or by computing the perceived similarity between *x'* and *x* (Weber, Thompson-Schill, Osherson, Haxby, & Parsons, 2009). The first process is known as category-based induction and the second as similarity-based induction (Sloutsky & Fisher, 2004). Similarity-based induction is applied when no conceptual information is given to children regarding the property of a novel object, and they have to rely on the physical similarity between the novel and the known object to infer the properties of the novel object (Sloutsky & Fisher, 2004; Sloutsky, Kloos, & Fisher, 2007; Welder & Graham, 2001). Children seem to develop the ability to make category-based inferences when they are 4 or 5 years old (Fisher & Sloutsky, 2005).

There is evidence for the use of similarity- and category-based induction when humans reason about the mental states of animals. When people are asked whether they believe that animals can experience mental states, two main trends emerge. First, attribution scores show a scala naturae distribution. That is, the attribution of intelligence (Driscoll, 1995; Nakajima et al., 2002), self-recognition, intention recognition, the ability to deceive (Eddy et al., 1993), the capacity for higher mental processes (Herzog & Galvin, 1997) and the attribution of empathic and communicative abilities (Harrison & Hall, 2010) are strongly correlated with perceived similarity and phylogenetic relatedness to humans. These findings support the hypothesis that similarity-based induction is used in attributing mental states to animals.

Second, not all attributions of mental states or abilities follow this distribution, since the kind of mental state in question also has an important influence on the inductive process. Basic mental states or abilities such as the ability to sense, perceive and feel are attributed more easily to a wide range of animals than complex mental states or higher cognitive abilities such as enumerating, sorting, morality, memory and foresight (Gray et al., 2007; Herzog & Galvin, 1997; Rasmussen, Rajecki, & Craft, 1993). Emotion attribution follows a similar trend. Primary emotions (fear, curiosity, joy, affection, surprise, sadness, anxiety, anger and disgust) are attributed more frequently to a wider range of animals than secondary emotions (embarrassment, shame, grief, guilt, empathy, pride and jealousy; Morris et al., 2008). We suggest that some mental states have more straightforward mental representations than others do; that is, people have a limited set of mental representations about what the state of being angry, happy, sad or surprised looks like. However, such mental images may not be available for cognitive states or abilities such as intelligence, memory or foresight, thereby affecting the inductive process.

Causal reasoning

Reflections on animals, nature in general and differences or similarities between humans and other animals are found in virtually all human cultures (Descola, 2006). These ideas about other living beings, which are shared within or even between cultures, are key elements used in reasoning about the mental states of animals. To give just an example, Descola (2006) proposed that the ontologies of living beings could be grouped into four categories: animism, totemism, analogism and naturalism. Animism, which seems a universal worldview of all hunter-gatherers, is particularly prevalent in many Native American, Siberian (Willerslev, 2004) and Amerindian cultures (Viveiros de Castro, 1998). It is characterized by a belief that all living beings share the same or similar 'interiorities', that is the same fundamental properties with regard to their inner essences, but it recognizes the dissimilarity in their physical aspect and behaviour. Naturalism, on the other hand, is based on the idea that humans share with all animals similar physical properties (cells, organs, tissues, etc.) but differ from them in other inner properties, essences or capacities. Therefore, any inference about the mental state of an animal by a person from an animistic culture might differ from that in a naturalistic culture, just because their underlying premises do not allow them to reach the same conclusions.

However, social traditions are only one component in building specific individual representations. People may also apply acquired knowledge about their social world, such as the learned associations between specific behaviours and their internal causes (e.g. hunger precedes eating), as well as the external causes that might trigger specific mental states (e.g. engaging in play induces joy). People frequently use such behavioural and contextual information when dealing with nonhuman animals, too (Horowitz & Bekoff, 2007; Mitchell & Hamm, 1997). For example, when people are told stories about animals, they tend to rely more on the description of the behaviour and its context when assessing emotions (jealousy) and intentions (deception) than on morphological similarity or phylogenetic closeness (Mitchell & Hamm, 1997). Likewise, dog owners tend to attribute pleasure and enjoyment to their dogs as a result of successful play bouts, that is, play sessions in which dogs and owners interact reciprocally (Horowitz & Bekoff, 2007).

RETHINKING ATTRIBUTION OF MENTAL STATES TO NONHUMAN ANIMALS

It seems that the attribution of mental states to animals is not simply a by-product of misplaced social cognition but is rather an

unavoidable consequence of the functional organization of the human brain. The physical network alone is insufficient to explain and predict the direction and speed of movement of a herd of running antelopes in the presence of a pride of lions, or the gaze of an eagle towards its potential prey. In most cases, information that rules the movement of objects cannot be used to predict the movement or behaviour of agents. Once agency is detected, a set of domain-specific and domain-general cognitive processes come into play to process the content of the mind of the subject in focus. The evidence reviewed here suggests the involvement of both automatic and reflective processes such as motor matching mechanisms and evolved schemata, as well as inductive and causal reasoning.

The activation of the social network, which is at the core of anthropomorphizing, may not always be triggered by default at the sight or sound of a living or living-seeming entity. Evidence suggests that the chronic suppression of the bottom-up response of the social network is possible. For example, Cheng et al. (2007) performed a study to compare the neural response of physicians and matched control participants to the observation of both hands and feet being pricked by a needle or just touched with a cotton bud (cotton swab). Seeing a needle prick activated the so-called pain matrix (dorsal anterior cingulate cortex, anterior insula and periaqueductal grey) in control participants, but not in physicians, who showed activated areas related to self-regulation and executive attention instead (Cheng et al., 2007). A subsequent study did indeed show that the specific neural responses of physicians are due to an inhibition of their bottom-up processing of pain perception (Decety, Yang, & Cheng, 2010). Paul & Podberscek (2000) found that veterinary students showed lower levels of empathy and belief in animal sentience during their third year of study than in their first. We believe that this might be the result of the chronic suppression of the social network when dealing with animals during veterinary education.

Since anthropomorphism is rooted in social cognition, we predict that individual differences in empathy or even ToM in humans will correlate with the tendency to attribute mental states to other species. This is supported by the finding that empathy is positively correlated with attitudes against the use of animals in research and in testing of nonmedical products (Furnham, McManus, & Scott, 2003), with attitudes towards animal welfare (Taylor & Signal, 2005) and with beliefs in animal mind and empathy towards animals (Apostol, Rebeca, & Miclea, 2013). The more individuals are empathic, the more they respond to perceived animal pain or misfortune (Norrington, Wikman, Hokkanen, Kujala, & Hänninen, 2014; Westbury & Neumann, 2008). Additionally, gender, one of the strongest predictors of concerns about animal welfare (Kellert & Berry, 1987), is consistently correlated with empathy (Baron-Cohen, 2002; Baron-Cohen & Wheelwright, 2004). Women generally score higher than men on various measures of positive attitudes towards animals, show less approval towards the use of animals for medical and scientific research, and score higher in the animal attitude scale (Driscoll, 1995; Furnham et al., 2003; Knight, Vrij, Cherryman, & Nunukoosing, 2004; Swami, Furnham, & Christopher, 2008; Taylor & Signal, 2005). Women also show stronger affective and weaker utilitarian attitudes towards nonhuman animals than men, a greater concern for animal cruelty issues, less support for their exploitation and subordination, and a greater concern for animal rights and welfare (Kellert & Berry, 1987; Phillips et al., 2011).

Waytz et al. (2010) predicted that the tendency to anthropomorphize would increase in conditions of causal uncertainty and in situations of high cognitive load. Cognitive load refers to the extent of working memory available for the processing of information in the context of the entire relevant information to be processed at any given point in time (Engle, 2002). Baddeley

(1981) defined working memory as the brain system in charge of the temporary storing of information used in complex cognitive tasks such as reasoning, language comprehension and learning. The working memory system is restricted by the quantity of information that it can hold (Cowan, 2010), and by the time lapse during which information can be stored (Baddeley, Thomson, & Buchanan, 1975). Increasing one or both at a time will lead to a cognitive burden that reduces the mental resources to deal with any primary task.

We suggest that a high cognitive load might affect mental state attribution in very different ways depending on how it is triggered in the first place. In Fig. 1, we present an outline of the potential engagement of physical and social cognition via automatic and reflective processes in response to animated and unanimated entities. We propose that a high cognitive load could interfere with the suppression of the social network when triggered bottom-up and with its activation when triggered top-down. It could increase physiological responses to observed animal distress through the inhibition of the top-down suppression of automatic motor matching. In other words, a high cognitive load might increase anthropomorphism only when triggered automatically given the inhibition of executive functions capable of suppressing attributions. In contrast, when anthropomorphism is steered top-down a high cognitive load might instead prevent the emergence of anthropomorphic attributions (Fig. 1). Only when objects have

been chronically imbued with animate properties (e.g. animism), and subjects have been chronically objectified (e.g. sexualized women; Cikara, Eberhardt, & Fiske, 2011), cognitive load might not have such a strong effect or no influence at all. Given the relationship between stress and empathy (Martin et al., 2015), we expect the suppression of both bottom-up and top-down attributions only in the presence of a stress-inducing high cognitive load.

Although any kind of experience with animals will potentially trigger the intentional bias, not all species are processed the same way. Animals phylogenetically close to humans, such as chimpanzees, *Pan troglodytes*, differ so much from insects in terms of anatomy, size, locomotion and behaviour that seeing them will probably engage different processes (Fig. 2).

Automatic processes such as motor matching mechanisms will probably be engaged as a result of observing animals displaying behaviours that are familiar to humans, especially if their anatomy and general configuration resemble those of a person (Buccino et al., 2004; Kupferberg et al., 2012). Thus we hypothesize that the heterogeneity or homogeneity (i.e. variance) in the mental states attributed to a given target or behaviour will reflect the type of mechanisms involved. We suspect that high levels of agreement in the attribution of mental states will be seen when the processes involved are implicit or automatic, and a higher variance when reflective mechanisms such as causal reasoning are used.

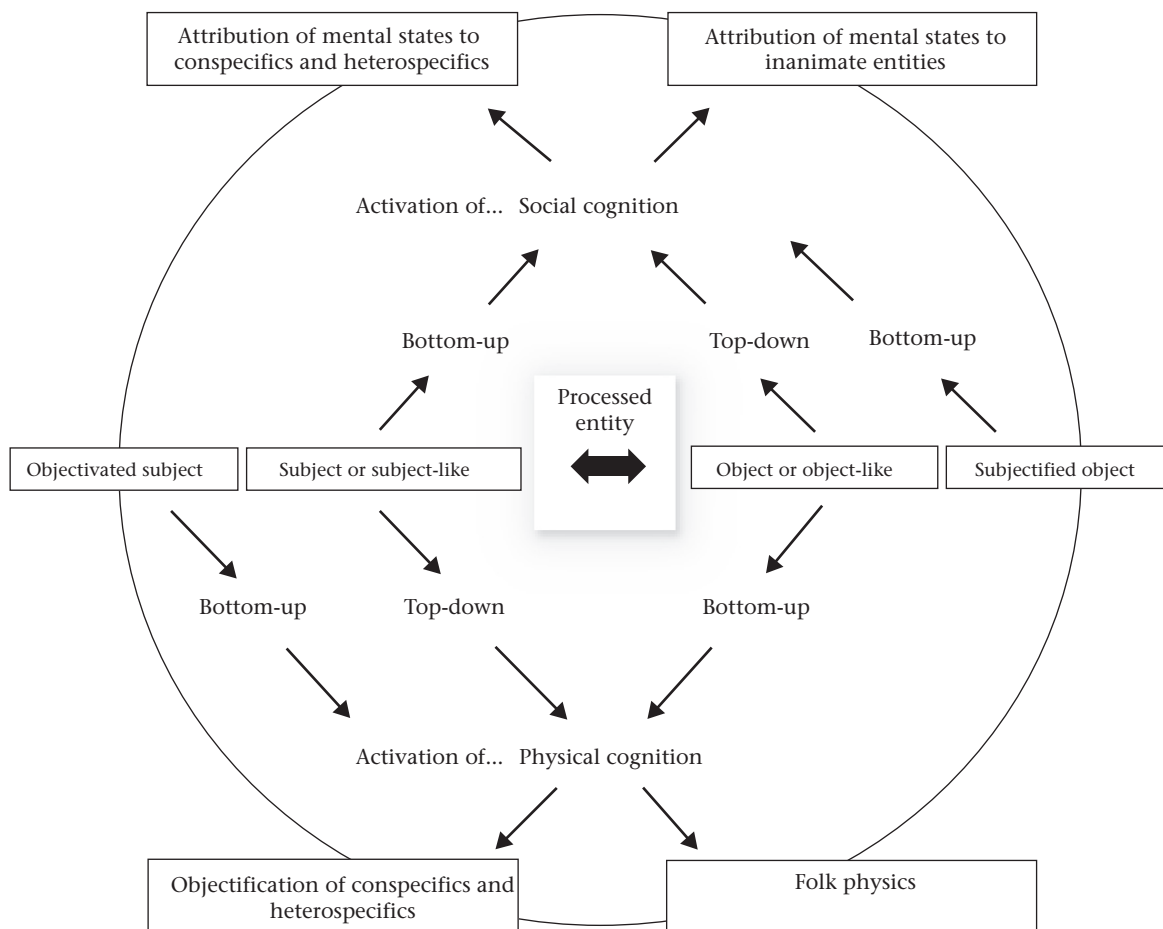


Figure 1. Engagement of physical and social cognition via automatic and reflective processes in response to animated and unanimated entities.

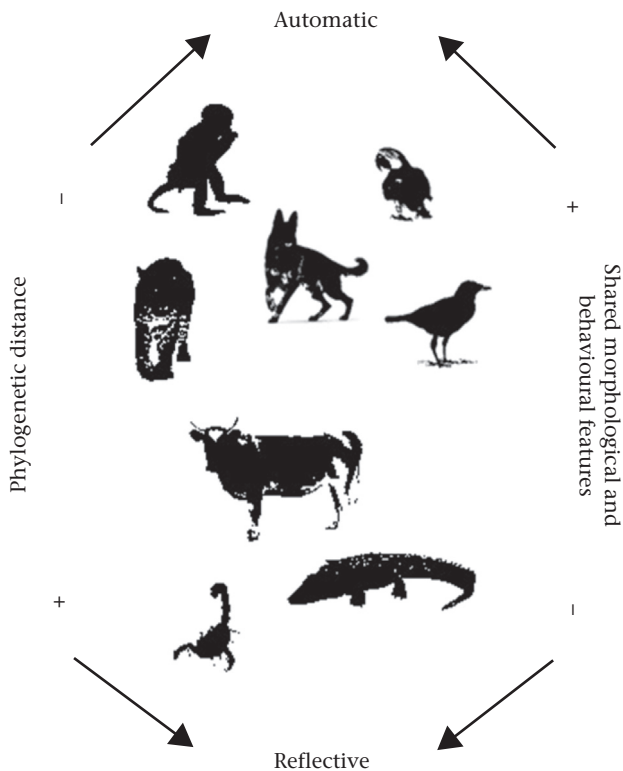


Figure 2. Hypothesized involvement of automatic and reflective cognitive processes according to human/nonhuman animal behavioural and morphological similarities.

DISCUSSION

Most previous hypotheses concerning anthropomorphism postulate the involvement of social cognitive processes in cross-species attribution of mental states. The cognitive default hypotheses proposed by Caporael and Heyes (1997) and Guthrie (1997) are supported by recent studies suggesting that the network for social cognition might indeed be the ‘default state of the brain’ (Iacoboni et al., 2004; Jack et al., 2013; Tavares et al., 2008). This is probably the case for other species as well, since the core social network governing the instinctive sociosexual behaviour in vertebrates has remained essentially unchanged in structure and function for some 500 million years, virtually from fish to mammals (Goodson, 2005). Hence, nonhuman animals may, as well, ‘animalize’ humans or other animated but nonliving entities, at least by employing their automatic neural processes. This is backed by observations that humans are not the only species that respond socially to nonliving stimuli. For example, studies in primates show that self-propelled motor devices with conspecific-like features trigger intention attribution in marmosets, *Callithrix jacchus* (Burkart, Kupferberg, Glasauer, & van Schaik, 2011; Kupferberg, Glasauer, & Burkart, 2013) and that humanoid robots imitating the actions of chimpanzees elicit social responses in the latter (Davila-Ross et al., 2014). These findings suggest that the intentional bias triggered by cues associated with living organisms evolved long before modern humans emerged and before the putative reorganization of the brain circuits may have occurred, as proposed by Mithen (1996). In contrast to the bottom-up activation of the social network, its activation in a top-down fashion may or may not be shared with other species.

There is also evidence supporting the interspecific behaviour recognition hypothesis. Humans may interpret animals based on broadly shared common biopsychological grounds involved in

coping with environmental, ecological and social challenges (Julius et al., 2012). Comparative organismic biology reveals a series of structures and mechanisms at different levels of behaviour, physiology and brain that are shared between humans and other animals. This includes a core network that governs the instinctive sociosexual behaviour in vertebrates (Goodson, 2005). This network links social stimuli with hormonal responses and is at the core of bonding (e.g. between mother and child and between sexual partners) and of ‘falling in love’, and is part of the brain that generates basic emotions shared at least within mammals (Panksepp, 2005). A number of other features add to the shared toolbox of humans and other animals for evaluating the world and for social interactions. These include the similarities between species concerning the principles of the expression of emotions and how expressions are decoded by others, the very conservative stress system and how they are linked with social behaviour (Julius et al., 2012), or the patterns of variability of individual behavioural phenotype (i.e. temperament, personality) in groups and populations (Sih, Bell, & Johnson, 2004). Such closeness in the ‘social tools’ will contribute to the engagement of automatic or bottom-up processing, thus prompting mental state attributions not only to be more difficult to avoid but also to be potentially more accurate. If this is the case, mental state attribution would also have adaptive aspects, as it would indeed create some basic predictability of the behaviour of animals. People may therefore not be completely off track when trying to avoid a growling dog or a hissing cat, but this is not always the case. For example, Meints, Racca, and Hickey (2010) found that 69% of the 4-year-old children they studied interpreted aggressive facial expressions in dogs as happy and smiling. Children were clearly using the exposed teeth common in a smiling person as a cue and matching it with the same feature in the dog. Interpreting an animal yawning as bored or relaxed, or a staring gorilla as interested might indeed have some negative consequences for the individual making such a mistake. Still, the question about the accuracy of mental state attribution to other animals cannot be answered here and is outside the scope of this review.

Early on, Dennett (1971) suggested that individuals engage in different strategies when trying to predict the behaviour of different entities in the world. The ‘physical stance’ works with intuitive notions about physics, and is used whenever an individual is trying to predict the trajectory of a kicked ball, a falling tree trunk or when handling tools. The behaviour of subjects cannot be predicted by just using these rules. When dealing with subjects, the best predictive strategy is to use the ‘intentional stance’ that is implemented by a host of cognitive mechanisms subsumed by the so-called social network. This might explain why the spontaneous attribution of mind to nonhuman animals is literally unavoidable.

The identification of the potential mechanisms involved in anthropomorphic thinking should support more specific hypotheses and predictions about the attribution of mental states not only to animals but also to robots or other real or imagined human-like entities. It also raises a wide range of interesting questions with important ramifications for understanding the interaction between both networks in mind attribution. For example, given that the brain’s social network underlies some of the attributions of mental states to nonhuman animals, what would be the consequences of reasoning about them in nonsocial terms, as economic goods, for example? Could the differential activation of the social and physical networks explain the discrepancy in the treatment of animals used as commodities versus pet animals? Examining the nature and consequences of these interactions has the potential to provide a new perspective on social exclusion, dehumanization, infrahumanization and sexual objectification, given the involvement of mind attribution as its core feature (Waytz, Schroeder, & Epley, 2014).

Conclusion

Anthropomorphic interpretations of nonhuman entities, especially animals, are supported by a set of cognitive mechanisms. Some of these processes, including motor matching mechanisms, evolved schemata and empathy for pain from the social cognition domain, are probably engaged in anthropomorphizing and mind attribution in an automatic way. Attributions emerging through these processes are expected to show a low intra- and interindividual variance, and to be less affected by cultural differences between people or by high cognitive load. In fact, a high cognitive load might interfere with the suppression of these automatically triggered attributions, rendering them more conspicuous and inevitable. By contrast, attributions resulting from processes that are more reflective are expected to show a greater intra- and interindividual variance, to be influenced by cultural differences and to be affected by a high cognitive load. However, as these mechanisms communicate and interact, anthropomorphic attributions will always be affected, to varying degrees, by both automatic and reflexive processes.

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