# THE COGNITIVE UNDERPINNINGS OF ANTHROPOMORPHISM

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# THE COGNITIVE UNDERPINNINGS OF ANTHROPOMORPHISM

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Image: Andrea Mantegna, Minerve chassant les Vices du Jardin de la Vertu (detail). Photo (C) RMN-Grand Palais (musée du Louvre) / Gérard Blot

The attribution of human traits to non-humans - animals, artifacts or even natural events - is an attitude, deeply grounded in human mind. It is frequent to see children addressing dolls and figures as if they were alive. Adults often attribute mental states and emotions to animals. In everyday life humans speak of events such as fires as if they possessed some form of intentionality, a behavior sometimes shared also by scientists. Furthermore, a systematized form of anthropomorphism underlies most religions. The pervasiveness of this phenomenon makes it a particularly interesting object of psychological enquiry.

Psychologists have set out to understand which aspects of human mind are involved in this behavior, its motivations and the circumstances favoring its enactment. Moreover, there is an ongoing debate among scientists about the merits or harm of anthropomorphism in the scientific study of animal behavior and in scientific discourse.

Despite the interest and the specificity of the topic most of the relevant studies are scattered across disciplines and have not built a systematic research framework. This observation has motivated the collection of articles presented here, under the unifying perspective of the cognitive underpinnings of anthropomorphism. Within this general umbrella, the authors included in this e-book have explored the issues mentioned above from different points of view. From their work it emerges that far from being the result of naive beliefs, the exercise of anthropomorphism involves a multiplicity of mental abilities including perception and imagination. They also show that the context and the interactive situation are crucial to understanding this phenomenon. Some authors analyze the relationship between anthropomorphization and theory of mind abilities both in typical and atypical populations. Finally, others contributions have identified possible benefits deriving from the natural attitude to anthropomorphize, as a design philosophy for robots and artifacts in general, or as a useful heuristic in the scientific study of animal behavior.

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EDITORIAL
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# Editorial: The Cognitive Underpinnings of Anthropomorphism

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**Editorial on the Research Topic**

**The Cognitive Underpinnings of Anthropomorphism**

Human beings frequently attribute anthropomorphic features, motivations and behaviors to animals, artifacts, and natural phenomena. Historically, many interpretations of this attitude have been provided within different disciplines (Guthrie, 1993). The attitude of treating artifacts or animals as if they were humans occurs very early in life appearing to be a fundamental aspect of human cognition (Epley et al., 2007; Dacey, 2017). In this Research Topic we set out to investigate some aspects of this phenomenon that are debated in contemporary research in cognitive science.

A first issue concerns how anthropomorphism is acquired and what is the relationship between adults and children's manifestations of this phenomenon. Can we still subscribe to Piaget's view that described animism as a typical children's form of thought (Piaget, 1926/1929)? Is there a relationship between anthropomorphism and pretense and role play? Connected to this there is the question whether anthropomorphism is the product of beliefs—and then linked to human-likeness or assumed complexity of an object or an animal—or instead can be observed only in the context of specific interactions.

Airenti in her paper discusses the acquisition of anthropomorphism in pretend play. She challenges two common views, that everyday forms of anthropomorphism are grounded in beliefs systems and that children would be more prone to anthropomorphism than adults. She argues that anthropomorphism is instead a form of communicative interaction in which a non-human entity takes the place that is generally attributed to a human interlocutor, a format implying the automatic attribution of mental and affective states.

The relation between role play and anthropomorphism in children is the central topic of the work of Severson and Woodard. In their study they analyze individual differences in role play and anthropomorphism in children 5, 7, and 9 years old. Their results provide evidence for a positive relation between the tendency to engage in role play and the tendency to anthropomorphize. They argue that role play and anthropomorphism potentially rely on a common simulation process of imagining others' minds and internal states.

Servais criticizes the definition of anthropomorphism as the attribution of human characteristics to a non-human being, proposing instead a pragmatist view of anthropomorphism. Based on anthropological and ethological literature she analyzes different forms of human-animal interactions, both in everyday life and biomedical laboratories. This evidence shows that anthropomorphism is not the attribution of human qualities to an animal according to a similarity gradient but the situated direct perception of animal minds by someone who is engaged in a specific interaction with them.

Another issue, which is considered in studies on anthropomorphism is how individual variability manifests (Waytz et al., 2010).

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Shaman et al. try to determine the underlying structure of individuals' anthropomorphic concept of God, whether there are cultural and experiential predictors of that structure, and whether individuals are consistent in how they anthropomorphize concepts of God in three domains. They assess individuals' attribution of anthropomorphic properties to God in the psychological, biological, and physical domain. They propose an analysis of how these domains relate to one another and an exploration of the experiential and personal factors that contribute to individual differences in anthropomorphizing across these three domains.

A particularly interesting case of difference in the practice of anthropomorphism can be found in clinical groups. Atherton and Cross review the literature about theory of mind and anthropomorphism in relation to individuals with Autism Spectrum Disorder (ASD). From their analysis it appears that ToM abilities which are usually impaired in this population, may be ameliorated, spared, or even enhanced when they are directed toward anthropomorphic rather than human agents. Evidence suggests that individuals with ASD may find anthropomorphic stimuli more socially motivating than human stimuli. This finding leads the authors to conclude that engagement with anthropomorphic stimuli may be used to enhance ToM abilities in this population.

Scientists are no exception, they are as inclined to anthropomorphism as lay people. Therefore, it is worth investigating the effect of anthropomorphism in the scientific practice. Varella identifies three distinct stances underlying mental anthropomorphism in action within biological sciences: the design stance, the basic-goal stance and the belief stance. For example, the design stance may be responsible for the mistaken conviction that function is the only explanation for why traits evolve. By adopting the belief stance the evolutionary gene's point of view is equated to human personal intention. Varella is particularly concerned with misunderstanding about natural selection by biology students caused by anthropomorphism.

Bruni et al. are less worried about the implication of anthropomorphism in the scientific research. Even if anthropomorphism is inherently a logical mistake, they argue that the use of humans as a model in scientific explanation has heuristic advantages, both in everyday circumstances and in the scientific enterprise. Ground for this claim is found in several animal studies, where a careful application of anthropomorphism has led to important discoveries.

Finally, a present theme of debate is the role of anthropomorphism in the design and management of robots and artifacts in general.

Damiano and Dumouchel propose a critical ethical approach to social robotics, which aims at allowing humans to use social robots for self-knowledge and moral growth. They take position in the debate, not only developing a series of arguments relevant to philosophy of mind, cognitive sciences, and robotic AI, but also asking what social robotics can teach us about anthropomorphism. They propose a theoretical perspective that characterizes anthropomorphism as a basic mechanism of interaction, and rebuts the ethical reflection that a priori condemns anthropomorphism-based social robots.

A second contribution in the "applied anthropomorphism" domain is due to Lee et al., demonstrating that anthropomorphism as a design philosophy can have a wide range of applications. The technological object of their study is a flexible display, and they found that the shape of the bend display enables emotional interaction with the users. Unlike the five standard emotions of facial expressions, the device elicited three groups of emotions: happiness, sadness-fear and anger-disgust. Moreover, only a few of the possible shapes of the device evoked high emotional responses.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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# The Development of Anthropomorphism in Interaction: Intersubjectivity, Imagination, and Theory of Mind

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Human beings frequently attribute anthropomorphic features, motivations and behaviors to animals, artifacts, and natural phenomena. Historically, many interpretations of this attitude have been provided within different disciplines. What most interpretations have in common is distinguishing children's manifestations of this attitude, which are considered "natural," from adults' occurrences, which must be explained by resorting to particular circumstances. In this article, I argue that anthropomorphism is not grounded in specific belief systems but rather in interaction. In interaction, a non-human entity assumes a place that generally is attributed to a human interlocutor, which means that it is independent of the beliefs that people may have about the nature and features of the entities that are anthropomorphized. This perspective allows us to explain the problems that emerge if we consider anthropomorphism as a belief: (i) adults under certain circumstances may anthropomorphize entities even if they perfectly know that these entities have no mental life; (ii) according to the situation, the same entity may be anthropomorphized or treated as an object; (iii) there is no consistency among the entities that are anthropomorphized; (iv) there is individual variability in anthropomorphization, and this variability derives from affective states rather than from different degrees of knowledge about the entity that is anthropomorphized or greater or lesser naivety of the person who anthropomorphizes. From this perspective, anthropomorphism is a basic human attitude that begins in infants and persists throughout life. The difference between adults and children is not qualitative but rather a matter of complexity.

**Keywords: anthropomorphism, development, pretense, intersubjectivity, theory of mind, imagination**



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## INTRODUCTION

Human beings frequently attribute anthropomorphic features, motivations and behaviors to animals, artifacts, and natural phenomena. Historically, many interpretations of this attitude have been provided within different disciplines (see Guthrie, 1993 for an extensive treatment of various perspectives). What most interpretations have in common is that they distinguish children's manifestations of this attitude, which are considered "natural," from adults' occurrences, which are considered exceptional and must be explained (Caporael and Heyes, 1997;

Epley et al., 2007; Dacey, 2017). Particular circumstances, for instance, uncertainty, fear, helplessness would justify among adults the attribution of anthropomorphic characteristics to invisible and threatening causes of diseases, such as bacteria or viruses. Some particularly dangerous natural events, such as thunderstorms or fires, may also be described in anthropomorphic terms.

A notable exception to the idea, originally introduced in developmental psychology by Piaget (1926/1929), that animism is primarily children's manifestation of irrational thinking, which is overtaken in adult life, is the position expressed by Guthrie (1993). Guthrie maintains that animism and anthropomorphism, far from being irrational, are reasonable answers to the ambiguity of the perceptual world. Guthrie proposes the following example. If you are jogging in a region that is well known for the presence of bears, at a first glance, you will most likely misinterpret boulders as bears. In fact, these momentary illusions show that people respond to perceptual ambiguity using the strategy of "better safe than sorry." This strategy is dictated by the necessity to discover possible real threatening agents, and it is not specifically human but rather shared with other animals (Guthrie, 2002). According to this view, animism and anthropomorphism should be considered on a continuum. People interpret the world with humanlike models because human thought and action are the highest organization that they know. Religious anthropomorphism is then the "highest pitch" of a strategy of attributing to the external environment as much order and meaning as possible.

In the following, I shall argue that Piaget's position claiming that children are particularly prone to anthropomorphism because they have not yet developed rational thinking is untenable. I shall also argue that Guthrie's definition of anthropomorphism in terms of an adaptive form of perception does not account for the use of anthropomorphism in everyday life. I shall argue that anthropomorphism is a particular form of interaction with non-humans that children implement early in their development and that persists in adult life.

I will begin my argument by discussing the very concept of anthropomorphism.

## WHAT ANTHROPOMORPHISM IS AND WHAT IT IS NOT

Let us first define animism, anthropomorphism and their relation.

The term animism is generally used to refer to the attribution of intentional action and a general concept of "life" to objects and natural phenomena. Anthropomorphism is more specifically the attribution of human mental states or affects to non-humans. These two concepts are distinct and at the same time strictly connected. We could say that animism is a weaker form of anthropomorphism. However, when humans attribute life to non-humans, they often also attribute to them human mental and affective states.

To outline all of the forms that animism and anthropomorphism can take is a major task. Let us try, nevertheless, to propose some distinctions.

A first phenomenon that we could define as anthropomorphism is perceptual. This phenomenon is illustrated, for instance, by "seeing faces in the clouds," to quote Guthrie (1993). Humans may identify perceptual characteristics of living beings in natural objects. For example, we can see a human face in the moon or a horse in the clouds. This form of imagination seems to be very basic in humans. We find fascinating examples of this in prehistoric caves, where sometimes we discover that the natural form of a wall has been underlined by a painter, who in this manner made it appear that s/he "saw" in it the outline of an animal. Humans frequently use fantasy to go beyond sheer facts and include simple objects or images in narrative contexts, which make them appear more appealing and meaningful. However, I doubt that phenomena of this type may be considered as a form of animism or anthropomorphism rather than a simple manifestation of human imagination. In fact, the perceptual aspect, the mere recognition of a human or animal form does not correspond to the definition of animism, even in its weaker form. After all, the recognition of human or animal features in a group of clouds is only one possibility among others. In clouds, we may see also artifacts, such as a coach, or other natural objects, such as a waterfall or a tree.

The process of imaginary transformation may become particularly salient in some cases when our fantasy is elicited by strong feelings. The fact that we can see a dangerous animal in a rock is not different from transforming an accidental noise behind us when we are walking on a dark and solitary street into the footsteps of a potential attacker. On other occasions, we can momentarily recognize in a stranger walking on the street someone that we long to see even if we know that it is not possible. In these situations, we materialize the objects of our fears or desires. However, these are brief illusions that quickly disappear.

As maintained by Guthrie (2002), there are reasons to think that these illusions are also present in the animal world. He proposes examples, some of them taken from von Uexküll (1934/1992). For instance, a starling was observed catching, capturing and finally swallowing a fly that was not there, a "magic" phenomenon according to Uexküll, and a product of imagination according to Guthrie. In this case, a strong "feeding tone" in the starling world would have "forced" the imaginary fly to appear in the absence of a real stimulus. Such a situation supports Guthrie's point of view that there is no neat separation between humans and other animals when imagination is an almost instinctive response to the environment, dictated by the subject's present world "tone," to use Uexküll's beautiful expression. However, here again we are not considering a case of animism. A phenomenon of this type is simply, at least in the human world, an unintended mistake. If a person is able to recover her or his cool head, the illusion disappears, and she or he immediately recognizes the misinterpretation.

Thus, contrary to Guthrie, I consider that anthropomorphism - also in its weaker form, i.e., animism – is not of a perceptual nature. Just seeing a human face in the moon is not an attribution of intentional life. What may transform our imagining the moon as a face from a simple fantasy into an anthropomorphic experience is the fact that we attribute an intentional stance to that face. We can imagine, for instance, that the moon looks back at us and that attitude could be defined as animistic. Anthropomorphism would appear, for instance, when, once this attribution of a simple intentional state is realized, we may start to think that the face shares our sadness or happiness or that it questions us, or we may even see it as menacing or foolishly indifferent to our feelings.

Following this approach, one may say that even in the case of threatening events such as a thunderstorm, fire, or disease, it is not the event itself that is anthropomorphized but rather the relation that a person establishes with it. A typical context that is suggested in these circumstances is a battle in which people feel engaged against the aggression of an evil force/intentionality that aims to destroy them or their assets. The language used is explicitly intentional, and this justifies an equally intentional response. For example, American firefighters "see forest fires as devious and as lying in wait," and think that they must track them down (Guthrie, 1993). The personification of fatal diseases transforms the period of illness that a person painfully endures into a fight and death into the heroic fall in a battle. In a radio broadcast, a high-level athlete who had to interrupt her activity due to physical problems described her coming back to competition as the result of her managing making a deal with her body that was personified and observed as separate from her.

What we have said about natural facts or events is much more evident when we analyze the other possible objects of anthropomorphization, i.e., artifacts and animals. Regarding artifacts, we anthropomorphize those that "do" something for or with us. Not surprisingly, robots or computers are the mechanisms that we most anthropomorphize, as they are purposefully constructed to interact with humans (Airenti, 2015b).[1] However, simpler devices that produce a useful activity, such as a coffee maker, a cash machine, or an alarm clock, are also supposed to "cooperate" with us. We may also anthropomorphize objects that we see as obstacles to our action, such as a door that does not open. We may even curse the door as if it intentionally resisted our attempts to open it. In fact, cooperation and hindering are connected, as we feel as an obstacle the fact that something that *should* cooperate with us actually does not. A door should be cooperative and let itself be opened. Thus, any object that can cooperate with us or hinder our activity may be the target of an anthropomorphic attitude.

Finally, humans may anthropomorphize animals. For animals, the process of anthropomorphization is more subtle because animals are living beings and do have cognitive capacities. The study of animal cognition, which assesses cognitive abilities across species and their similarities with humans, poses many methodological problems. However, it is largely accepted that animals have cognitive systems (Andrews, 2015). Most animals experience pain-like states (Bateson, 1991; Sneddon et al., 2014) and have at least basic emotions (Panksepp and Biven, 2012). Thus, the attribution of a mental life to animals is not completely due to anthropomorphism. However, the interesting point here is that the anthropomorphization of animals does not always occur, and it is often difficult to explain why the process of anthropomorphization is enacted in certain cases and not in others.

Eddy et al. (1993) found that a number of factors influenced human subjects' attribution of cognitive abilities to animals, including perceived similarity of the animal to humans, its phylogenetic group membership and, in the case of dogs and cats, the degree to which they had formed an attachment bond with a particular animal. It seems natural that a higher level of anthropomorphization is triggered by pets, who are often considered companions with whom one can share her or his life. In fact, it has been shown that ownership of animals influences the reporting of emotions in animals, in particular secondary emotions (Morris et al., 2012). A study has shown that ownership of birds, rabbits, and rodents significantly increases the number of emotions that are attributed to those species (Wilkins et al., 2015). However, this study also showed that emotions are not consistently attributed even among mammals. The great majority of the participants also attributed secondary emotions to dogs. Only a few attributed them to cows. This result can be explained by the fact that in modern urban life, dogs are pets and cows are not. At the same time, participants also attributed emotions to animals that society either destroys as pests or keeps to use. Also, unexpectedly, Podberscek (2009) found that South Koreans might be in favor of keeping dogs as pets and at the same time against a ban on dog eating. On the other hand, most South Korean people were against both eating cats and keeping them as pets.

Thus, evidence shows that humans are rather incoherent in their attitudes toward animals. According to Serpell (2009), this incoherence is explained by humans' desire to maintain the possibility of both having animals as companions and using them for their needs. To this aim, they "compartmentalize" and establish differences between animals, differentiating also the obligations that they have toward them. This disparity is supported by the fact that, as it has been shown, anthropomorphism is explained more by affection than by simple ownership. Increased attachment levels result in the increased use of emotive terms to describe animal behavior (Kiesler et al., 2007). Other studies have shown that owners attribute advanced human capabilities and emotions to their own animals but not to animals owned by others (Fidler et al., 1996) and that owner attachment influences the attribution of mirrored emotions to animals (Martens et al., 2016). Thus, it appears that it is our relation to the animals that influences our beliefs about their human-likeness and not the other way around.

This conclusion shows that even in the case of animals, which are living beings and thus most susceptible to being anthropomorphized, it is not the belief (for instance, regarding

[1]The problems created by perceptive similarity between robots and humans have been first exposed by Mori's work on the uncanny valley (Mori, 1970). Mori maintained that similarity to humans does not necessarily produce familiarity. In a graph considering familiarity as a function of robot's appearance, as robots appear more human-like, humans' sense of familiarity increases until a point where it plunges into the uncanny valley. Moore (2012) proposed a mathematical explanation of this effect. Gray and Wegner (2012) suggested that people may find robots "unnerving" because their appearance prompts attributions of mind.

the existence of secondary emotions among them) that causes our attribution of human-like characteristics. The belief comes *a posteriori*, and it is often difficult to arrange it in a coherent and rational manner. It can also be noted that usually, transforming attitudes toward different animals into a coherent system of beliefs is not considered necessary. Inconsistencies are manifest only when researchers induce subjects to provide explicit judgments in experimental situations.

In the literature, the problem of anthropomorphism toward animals is particularly debated due to the moral issues that it involves.[2] My purpose here is not to contribute to these debates. My aim is to outline the emergence and development of anthropomorphism to better comprehend how it manifests in different situations and toward different objects. The most salient fact that appears from the brief summary provided above is that humans may anthropomorphize almost any object, event, or animal. The characteristics of these entities are too disparate to provide an explanation for anthropomorphism. What do reproaching one's car that does not start on an icy morning and accusing one's cat of jealousy have in common? If the similarity is not in the entities that are the target of the process of anthropomorphization, we have to investigate the relational context in which anthropomorphism is activated. To pursue this aim, I will now analyze the beginning of anthropomorphism in young children.

## CHILDREN'S ANIMISM IN PIAGET'S VIEW

An analysis of animism in children was extensively performed by Piaget (1926/1929). He maintained that children have a spontaneous animist attitude that develops through different stages until around the age of 12. Piaget distinguishes two periods in children's animism. The first, lasting until the ages of 4 and 5, is characterized by what he calls an integral and implicit animism. When a child adopts this attitude, "anything may be endowed with both purpose [*intention* in the original] and conscious activity according to the occasional effects on the child's mind of such occurrences as a stone which refuses to be thrown on to a bank, a wall which can hurt the hand, etc." (p. 213). In the successive period, implicit animism progressively disappears, and the process of systematization begins to follow discernable stages. It is in this period that it is possible to question the child. It must be noted that Piaget's definition of animism includes anthropomorphism since in his examples children often attribute to entities of the world not only life and activity but also mental and affective states typical of human beings. Piaget writes, for instance, that "…the facts just stated show clearly enough the child's *belief* [italics is mine] in animism and in an animism that is not very theoretical (its object is not to explain natural phenomena), but affective. The sun and moon take an interest in us (*ibid.*, p. 220)."

One important point is how Piaget obtained his data about children. He asked them questions about their beliefs. For instance, he asked, "Does the sun move?" "Yes, when one walks, it follows. When one turns round it turns round too," answered Jac, a 6-year-old. Most of the children he questioned, including some 11- to 12-year-olds, gave similar answers. To these answers, he responded with questions such as "If you and I were both walking but in opposite directions which of us would it follow?" Piaget was aware that this form of direct questioning, including drawing attention to resulting inconsistencies, made children express in the form of a belief something that they most likely had never thought about before. He put them in a position to search for responses to questions they would never had spontaneously posed to themselves. Therefore, they had to strive to find a solution to contradictions they did not imagine. However, the similarity of responses produced by children of the same age made him confident about the reliability of his results.

It is interesting to analyze the bases on which Piaget poses the distinction between the first and second periods of children's animism. What does it mean that the first form of animism is implicit and integral in young children? For Piaget, at the beginning, children do not distinguish their own mental life from the external world. They think that everything in the world shares their own subjective life; between the self and the external world, there is *indissociation*. "Child animism presupposes a primitive state of belief in a continuum of consciousness" (*ibid.*, p. 231). Actually, children described all moving objects as conscious and every event as intentional. "The wall who hit me" said Nel, a 2.9-year-old girl who scratched herself against a wall, for instance. Natural objects are either good or naughty according to their activity; for instance, the rain may be naughty and the light nice. For a young child questioned by Piaget, the rain was naughty: "because Mummy pushes the pram and the pram all wet."

Later, children develop a systematic animism, i.e., a set of explicit animistic beliefs. These beliefs are based on the principle of *introjection*. "All that either resists or obeys the self is thought to possess an activity as distinct as that of the self which commands or tries to overcome the resistance" *(ibid.*, p. 242). The process of introjection derives from *egocentrism*, children's characteristic self-centeredness. In this phase, when pushed to explain their animistic beliefs – for instance, that the sun follows them when they walk – children try to find reasons, to manage contradictions, etc.

In conclusion, animism, in Piaget's view, is a step in the development of thought and is explained by the child's egocentrism. Later, when children develop causal thinking, they free themselves from this form of irrational reasoning. From this same perspective, Piaget thinks that animism in adults is present only among "primitive" people. Members of such societies, according to him, are completely dominated by respect for tradition and do not develop the cooperation that in advanced societies allows children to overcome egocentrism. As a consequence, they never attain, even as adults, the stage of rational thinking (Piaget, 1928).

[2]One much-debated question concerns the cognitive and affective abilities that different species actually possess. This problem is connected with questions concerning animal rights and human obligations to promote their wellbeing. Another question is whether attributing human-like characteristics to animals is useful for understanding their nature and needs (Root-Bernstein et al., 2013).

Many aspects of Piaget's vision of development have been challenged. In particular, the fact that infants do not distinguish their internal life from the external world has been contested (Trevarthen, 1980; Stern, 1985/2000). However, Piaget's point of view is still considered as the main reference regarding children's animism, including his idea of animism as a form of irrational thinking that, in modern societies, disappears in adult age.

On this topic, let me provide a few remarks.

The most general point that we can contest is that animism is mainly a child's (and a "primitive") disposition. As we have observed in the previous section, adults practice many forms of anthropomorphism, and anthropomorphism is involved in most religious thinking in all societies. Thus, it is difficult to attribute it to confusion between the self and the other, to egocentrism, and, in general, to underdeveloped reasoning abilities.

Another point concerns the distinction made by Piaget between two forms of animism and attributed by him to different stages of development. The first manifestations of animism that Piaget detects in young children's words are very similar to the situations in which adults resort to anthropomorphism. If it rains on a day when I planned gardening, I will most likely address the rain as if it were naughty and as if it intentionally hindered my activity. At the same time, Piaget introduces the principle of introjection, which connects animism to the idea of an object "obeying" or "resisting" the self. Actually, it is very difficult to detect in these interesting descriptions of children's forms of animism, as Piaget would like, different steps of the development of rational thinking. The developmental path from indissociation to introjection is rather obscure, and it appears that there is no clear distinction between the first forms of animism and the manifestations of introjection that Piaget attributes to the phase of systematization. In all cases, Piaget refers to *beliefs* that children entertain. In fact, his questioning of children in the phase of systematization is mostly about the sun and the moon and children's ideas that they act as intentional beings interested in humans' life. These ideas are presented as *explicit beliefs* or at least as beliefs that become explicit when children must answer questions about them. I argue that the adoption of the concept of belief, both implicit and explicit, in these situations must be analyzed in more detail. Does the fact that a child says that the rain is naughty mean that s/he *believes* that the rain is an intentional being? We do not expect that this would be the case for an adult in the same circumstances. Are children's ideas about the sun and the moon beliefs or rather fantasies? We can consider that children's lack of knowledge about the physical reality might be replaced by fantasies. Moreover, the fact that things are different from what they appear to be is something that must be learned. For centuries, humans believed that the sun goes around the earth, and according of a survey performed by the American National Science Foundation in 2014 (reported by Time), one in four Americans questioned about this topic gave the incorrect answer.

Connected with what is presented above, there is a third question posed by Piaget himself. It concerns the role that language plays in children's animistic expressions and what they take from adults' discourse. Piaget concedes that adults often use finalistic language, producing, for instance, expressions like "the sun is trying to break through the mist" (*ibid.*, p. 248) However, in his view, language is not the cause of animism because this is the natural manner of children's thinking. The similarity between adults and children would be only apparent because children take literally what for adults are only metaphors. Developmental research has shown that this is not the case, at least with respect to the distinction between physical and mental objects. Children by age 3 may use physical language to describe mental phenomena (as adult do), but they are aware of their different natures. A real object can be touched, whereas the thought or memory of the same object cannot be (Wellman, 1990). Thus also in the case of animism, we should be cautious to attribute a belief using mere linguistic evidence.

A final point regards an aspect missing from Piaget's analysis. Actually, in his analysis of anthropomorphism, he never mentions pretense. He considers animism as an underdeveloped form of thinking, and he does not contemplate the connection that it might have with the world, so important for children, of pretense and fantasy. In pretend play, children attribute at least animacy, but often also mental and affective states, to puppets, dolls, stuffed animals, fictional characters, and even simpler objects, such as blocks or pebbles. The fact that children at 18 months start to deal with narrative and fantasy situations in which intentionality and other mental and affective states are attributed to non-humans is possibly connected to other forms of animism that children perform. Moreover, young children are often involved in relations with house pets that they consider as companions and with whom they play. It must also be stressed that these forms of animism are often favored by adults who consider them suitable for children.

In conclusion, are we confronted with different forms of anthropomorphism (implicit and explicit, for instance) in the cognitive development of the child? Do we have to appreciate the role played by language? Is there a relationship with pretend play? To provide an adequate account of anthropomorphism, we should consider all of these aspects, which will allow us to distance ourselves from the too-simple vision that animism can be reduced to children's naive beliefs about entities of the world. Actually, anthropomorphism is a much more pervasive attitude that starts early and persists in different manners throughout life. Moreover, it plays an important part in the interactions between children and adults.

## THE DEVELOPMENT OF ANTHROPOMORPHIC THINKING: FROM OBJECTS IN MOTION TO PRETENSE

The tendency to interpret in human terms very simple objects in motion has been demonstrated in a long experimental tradition since the seminal work of Heider and Simmel (1944). They showed subjects a brief film in which three geometrical figures – a large triangle, a small triangle, and a circle – appeared, moving in different directions and at different speeds. The only other figure in the field was a rectangle, a section of which could be opened and closed. When asked to describe the scene, most subjects interpreted the movements of the geometrical figures as the actions of human beings and as part of a connected story. These results were replicated with adults (Oatley and Yuill, 1985) and children (Berry and Springer, 1993; Springer et al., 1996), and what is particularly interesting is that young children succeeded in adapted versions of this experimental paradigm. Montgomery and Montgomery (1999) showed that by the age of 3, children inferred goals from the movement of balls and distinguished goals from the outcomes of the acts. Gergely et al. (1995) showed that 12-month-old children expected that colored dots on a screen pursued their goals as an intentional actor would do and were surprised if this was not the case.

Researchers have tried to identify the visual cues that produce the effect of animacy and to elucidate the relation between perception and higher-level forms of inference (Dasser et al., 1989; Scholl and Tremoulet, 2000; Scholl and Gao, 2013; van Buren et al., 2016). However, for the present argument, the point is that when seeing forms in coherent motion, humans since a very young age naturally attribute to them intentionality and reciprocal interactions; for instance, they think that a figure is chasing another or tries to join it.

Along the same lines are the results of experiments regarding the development of sociomoral evaluation in infants. In this experimental paradigm, infants viewed a colored wooden block with eyes attempting to achieve a goal, i.e., climb a hill. The attempt could be facilitated or hindered by another block, who pushed the protagonist up or down the hill. By 3 months, infants looked longer at individuals who facilitated the protagonist's goal than at those that blocked its goal (Hamlin et al., 2007, 2010). This experimental paradigm in all its variations has allowed for the formulation of very interesting hypotheses about intuitive morality in infants (Wynn and Bloom, 2013; Van de Vondervoort and Hamlin, 2016).[3] Regarding anthropomorphism, one aspect is particularly relevant. The evaluations are made possible by the fact that infants naturally attribute good or evil intentions to geometrical objects moving on a screen. Let us focus on the developmental path. If we compare the interpretations of the movements of simple objects made by adults with those made by children, the difference between them seems to be only in terms of complexity. As Heider and Simmel (1944) show, adults may imagine complex stories involving the "characters," whereas the younger the children, the simpler the reaction. In infants, we can register only surprise if the "actors" do not coherently pursue their supposed goals or a preference for cooperative behavior over a hindering one. However, the anthropomorphic attribution is present in both groups. When objects move in a coherent manner with respect to one another, they are not only interpreted as causally linked (Michotte, 1946/1963) but also as interacting.

A particularly interesting point is that the language used to describe these situations is affected. As we have observed in the studies with infants mentioned above, the researchers themselves describe the experimental situation using anthropomorphic language, a block *pushing* the other up or down. Actually, describing the situation in purely geometrical objective terms would be difficult, long, and barely comprehensible, as Heider and Simmel write in the *Methods* section of their paper: "A few 'anthropomorphic' words are used since a description in purely geometrical terms would be too complicated and too difficult to understand" (p. 245). Thus, not only the experimental subjects but also the authors of the studies and the readers are involved in anthropomorphic attribution. We find exceptions to anthropomorphic interpretation of objects in motion only in clinical groups, such as persons with autism spectrum disorders (Abell et al., 2000; Klin, 2000).

A fundamental feature of anthropomorphism that appears already in infancy is the fact that in these interactions, two possible roles are attributed to the actors. One character may either cooperate with or be an obstacle to the other's supposed goals (Tomasello and Vaish, 2013). According to the age of the subjects, this simple dichotomic distinction may appear at different levels of elaboration, but it is still present in adult anthropomorphization of objects. As said before, in everyday life, we expect that objects *cooperate* with us to ensure the success of our activities. In general, this "collaboration" is not an issue (people do not wonder about their coffee maker's intention to produce coffee), but when some event compels them to focus on their relation with the object, such as when they are unsure about how to proceed or fail to reach their goal, the object enters the focus of attention and may be anthropomorphized. One can address it and invite it to be more collaborative or blame it as an obstacle to achieving the intended goal, for example.

The analysis of the geometrical objects in motion may be pursued further. The original experiment showed that adults were very easily induced to connect the simple acts performed by the figures and construct stories. This observation means that even the simplest situations may trigger the process of imagination. The geometrical figures are not only perceived as acting in a manner related to each other but also attributed mental and affective states. For instance, in Heider and Simmel's experiment, two triangles were described by adults as two men fighting for a girl (represented by a circle). In this case, the adults were exercising an ability that begins with children as young as 12 months in pretend play (Fein, 1981).

Pretense in children involves both anthropomorphization and imagination. Young children may naturally produce situations similar to the ones proposed in the experiments mentioned before, for instance, using colored blocks to represent objects and imagine simple stories involving them. They anthropomorphize and construct stories with stuffed animals, puppets, and dolls. However, even when young children anthropomorphize the objects with which they play, they are not confused about their status. It has been shown that at least by age 3, children distinguish reality from pretense (Woolley and Wellman, 1990; Harris, 2000; Ma and Lillard, 2006) and that differences between children and adults reflect a continuous development (Woolley, 1997). Moreover, children's creation of imaginary worlds is often a social construction (Leslie, 2002) that involves adults. Already when they are 15-month-old, children engage with mothers in

[3]In the literature, there has been much debate concerning the replicability and robustness of findings obtained within this experimental paradigm (Hamlin et al., 2012a,b; Scarf et al., 2012a,b; Cowell and Decety, 2015; Hamlin, 2015; Salvadori et al., 2015; Nighbor et al., 2017). Surely more research will be necessary to define the concept of core morality. For my argument, the fact that infants attribute intentions to geometrical objects (a fact that is largely recognized by researchers adopting different approaches) is sufficient.

reciprocal imitation of pretense actions, and mothers' imitation predicts children's pretending (Markova and Legerstee, 2015).

The role of adults in leading children to anthropomorphism clearly appears in children's storybooks, cartoons, and movies, which often contain anthropomorphized animals and objects. The use of anthropomorphization of animals for children has been recently questioned in the literature, and a number of studies have shown that it does not necessarily enhance early learning (Richert et al., 2009; Ganea et al., 2014; Geerdts, 2016). From a theoretical point of view, the question is whether anthropomorphism is a natural form of thinking typical of young children that evolves in later years, as maintained by Carey (1985), or instead if it develops under the influence of adults and the cultural milieu. In this debate, the term anthropomorphism is often replaced by anthropocentrism to stress the fact that using human categories to understand other biological entities leads to mistaken representations. According to Carey, young children reason about animals from an anthropocentric point of view that is later abandoned due to a conceptual change. In contrast with this view, interesting results show that anthropomorphism in young children's dealing with biological entities is not universal. It seems to be absent, for instance, in rural cultures (Medin et al., 2010). Additionally, in urban cultures, it is not present at 3 years of age but rather develops later (Herrmann et al., 2010). What these studies show is that there is not a universal developmental stage that involves the extension of anthropomorphic features to unknown biological entities. Anthropomorphism is an attitude that children acquire in urban societies in which animals are not part of everyday life except as pets and companions.

The evidence presented in this section leads us to some conclusions about the human tendency for anthropomorphism. There are aspects of anthropomorphism that seem to be universal and that emerge very early in development. Let us summarize them.

(1) Humans rarely, if ever, interpret coherent movement of multiple entities without resorting to anthropomorphism, and this is true both for adults and for children since infancy. As we have observed, adults have no vocabulary other than anthropomorphic terms for these situations. The description in geometrical objective terms of what we call a block "pushing" another is difficult to produce and even more difficult to understand. This is more than a linguistic problem. Intentionality is the best model that humans have to describe these situations.
(2) The above observation means that causal thought is insufficient to explain these facts and that the entities are conceived as related and in interaction. One entity is perceived as trying to join or escape another, for instance. Thus, another anthropomorphic concept seems to be unavoidable, *relation*. Entities in a defined space that move in a coherent manner are related to one another as if they were human beings.
(3) A relation of this type has two basic forms of expression, cooperation, and competition. One entity may collaborate with another or be perceived as an obstacle. Again, this is true for children and for adults. Objects are perceived as helpers or hinderers. Thus, even in the simplest relational contexts, we do not find animism but rather anthropomorphism. Note that there is nothing in the object itself that makes it adapted to be anthropomorphized, nor is there any particular belief leading to anthropomorphic attribution of mentality. Anthropomorphism is grounded in the relation.
(4) Establishing these basic forms of relation implies evaluation. Infants already distinguish the two situations and exhibit a preference for the cooperative object over the non-cooperative one. The whole process is made possible by imagination. Objects acquire imaginary characteristics, including mental and affective states, and more complex relations may be evoked. This process starts in young children but is still present in adults even if the imaginary constructions may be differently elaborated in the two cases.

We can conclude that in humans from infancy to adulthood, there is a basic tendency to anthropomorphize entities under certain circumstances, i.e., that an entity be perceived as in a human-like relation with them.

It is important to stress that this attitude certainly appears in infancy but is present throughout life. Anthropomorphism is a specific human attitude, not a childish mistake. In this respect, separating young children's attitudes from adults' is unsuitable because it hides the fact that children construct their anthropomorphic attitudes in interactions with adults who not only normally use an anthropomorphic language but also share pretend play with children and propose to them entertainment in which anthropomorphism is dominant.

However, what about the anthropomorphization of animals? As we have observed, the experimental results do not confirm that it is universal in young children. On the contrary, it is acquired specifically in societies in which contact with animals is not frequent. As stressed by Herrmann et al. (2010), if we induce young children to categorize, they do so according to animacy, i.e., following the distinction between animate objects and inanimate objects, a distinction that young children already make in the first year of age (DeLoache et al., 2011).[4] This is consistent with experiments showing that children at 6 months of age exhibit a preference for natural situations in which an experimenter speaks with a person or grasps an object relative to unnatural situations in which the experimenter grasps a person or speaks to an object (Molina et al., 2004).

According to this perspective, the basic distinction that young children make is between animate and inanimate entities. On the contrary, attribution of specifically human features to animals would be acquired. Children who have no information about animals are taught to use the human model to interpret their behavior. Reciprocally, anthropomorphized animals are used to teach them behavioral and moral rules of human society. In societies in which animals coexist with humans, children better know about them and have more specific models to interpret

[4] Simion et al. (2008) have shown that discrimination between biological and non-biological motion and preference for biological motion is already present in 2-day-old babies.

their behavior. What is important here is that this claim applies to beliefs about animals and must be distinguished from interaction with them. When interacting with animals, children who have pets may treat them as companions and anthropomorphize them as adults do.

The previous remarks illustrate a fundamental distinction between anthropomorphism as a belief and anthropomorphism as it appears in interaction. In my perspective, to treat anthropomorphism as a system of beliefs without considering its relational aspect is a source of misunderstanding and potentially contradictory results. In the following, I shall argue this point in more detail.

## ANTHROPOMORPHISM IN INTERACTION

As we have observed, when anthropomorphism is defined as a system of beliefs, a distinction between strong and weak beliefs is often accepted. Beliefs may be strong, such as anthropomorphic traits attributed to God in many religions, or weak, as in the case of mental states momentarily attributed to objects such as a car or a computer. For instance, in their theory of anthropomorphism, Epley et al. (2007) maintain that the weaker forms are better described as "as if metaphorical reasoning." However, they conclude, "the difference between weak and strong versions of anthropomorphism, we suggest, is simply a matter of degree regarding the strength and behavioral consequences of a belief, not a fundamental difference in kind (p. 867)."

Let us examine why it is not useful to characterize anthropomorphism as a form of belief.

Let us consider the concept of a "strong belief" as part of an anthropomorphic system of beliefs. As we have discussed in Section "What Anthropomorphism is and What it is not," any entity can be anthropomorphized, including artifacts and biological entities such as plants and animals. People may anthropomorphize not only cats and dogs but also pests, robots or locks. There is no requirement of human-likeness or a high level of complexity. Moreover, the same entity may be treated by the same person alternately in both anthropomorphic and realistic manners, showing that this attitude is independent of the knowledge about the entity that one possesses. The uncertainty that a person may entertain about the real nature of an entity is not an explanation either. Obviously, anybody knows the fact that a mammal is much more similar to a human being than an insect, and people are more likely to attribute complex cognitive states to primates than to cockroaches (Eddy et al., 1993). Thus, people have a more or less conscious concept of *scala naturae.* However, under certain circumstances, an insect can also be anthropomorphized. Inversely, a cow may be objectified when it is used as food.

Let us look now at the idea of "weak belief." As we have observed, the metaphor model is presented by some authors as a weaker form of belief, a belief that has a reduced behavioral impact. Can the anthropomorphizing process be considered a form of metaphor? Actually, the metaphor model is too generic to explain the process of dealing with non-humans as if they were humans. Furthermore, the concept of metaphor is inadequate in this context because the aim of anthropomorphic process is not to describe a situation but rather to affect it. We have repeatedly observed that in anthropomorphic representations, the content is irrelevant. Only the relational context transforms a representation into an instance of anthropomorphism. The activation of the process of anthropomorphization of an object momentarily obscures the realistic knowledge about it that one has. However, the situation is easily reversed, and the object can be perceived again with its actual features. In all of the cases that we have observed, anthropomorphization is never a question of degrees. It is an all or nothing attribution, a figure–ground relation.

My hypothesis is that to explain the existence of inconsistent points of view about the same object, we have to define the circumstances in which this shift from one point of view to the other occurs. Anthropomorphism is neither a belief in its stronger forms nor a metaphor in its weaker forms. Fundamentally, anthropomorphism is a way of relating with a non-human entity by addressing it as it were a human partner in a communicative situation.[5]

Anthropomorphizing objects or biological entities is a means to establish a relation with them, dealing with them as interlocutors in a communicative interaction. This process leads to the *automatic* attribution of intentionality and social behavior. The anthropomorphic relation has two basic modalities, cooperation and competition. When I establish this type of relationship, I expect that the entity cooperates to the achievement of my goals, and I use communicative means to urge cooperation. In case I perceive it as an obstacle, I fight to overcome it. Obviously, all of that is imaginary. My car will not become more efficient because I speak to it, and unfortunately, my chances to win a lottery will not increase because I implore fate to help me. The crucial point here is that no belief, weak or strong, is involved in this situation, simply because people do not believe that cars or lotteries have human minds.

The most natural means for humans to influence others' actions and to gain their cooperation is to communicate with them, and this implies the attribution of mental and affective states. This same modality is employed with non-human entities in the process of anthropomorphization. Thus, one can speak to, complain, scold, justify, compliment, etc. any entity that he or she intends to address. The motivations may be multiple, such as uncertainty, fear, desire, hope, etc., but the format is the only one that humans know how to use to influence others, i.e., enacting a communicative interaction. In the case of the establishment of an anthropomorphic relationship, it will be an imaginary one.

This model is compatible with the evidence that there are individual differences in anthropomorphism (Waytz et al., 2010). Some individuals who lack social connections and feel lonely may be more disposed to establish imaginary relations with non-human entities. In the same manner, a sick person may feel less

[5] I do not consider here anthropomorphism as it can be found in written or oral religious texts. In that case, we do have an explicit system of beliefs that people who adhere to one religion are supposed to share. However, these systems are built on anthropomorphic relationships (Severi, 2018).

weak and helpless if s/he consider his or her illness as an enemy to fight.

This approach allows us to see from a different perspective the comparison between adults and children with respect to anthropomorphism. The most accepted position maintains that there is variability among adults but that a fundamental difference exists between adults and children. Children would be more prone than adults to anthropomorphism (Epley et al., 2007). However, evidence shows that in both adults and children, anthropomorphism exhibits the same features.

We have defined anthropomorphism as a relation that a human establishes with a non-human entity. Such a relation is enacted by putting a non-human entity in the position of interlocutor in an imaginary communicative situation. Certainly, children are very soon acquainted with this format. On one hand, children participate in communicative interactions very precociously, well before language acquisition (Bateson, 1975; Bruner, 1975; Trevarthen, 1998; Liszkowski et al., 2012; Airenti, 2017). On the other hand, equally precociously, they learn to extend the communicative format to non-humans in pretense (Harris, 2000). We could even state that pretend play is the prototypical anthropomorphic communicative situation.

Children acquire the communicative format in interactions with adults, and in interaction with adults, they acquire the possibility to extend it to objects and biological entities, real or imaginary. Note that in their first interactions with infants, adults include them in communicative games in which children participate with simple sounds and smirks and adults with their much more complex gestural and verbal communicative repertoire. In these proto-dialogues, infants' behaviors are interpreted (and sometimes overinterpreted) as intentional responses (Newson, 1979). Adults attribute to them mental and affective states that they do not necessarily experience. Thus, adults, at least in our society, often anthropomorphize infants. At the same time, they anthropomorphize animals, real or represented, and use them to teach children different aspects of mental, social life, and moral rules. Thus, if children have an attitude toward anthropomorphization, adults are equally prone to anthropomorphization when they relate to infants. More precisely, parent–child communication often involves a non-human as a third partner. Think of an example of this type. A mother indicating the child's teddy bear tells her, "Look, he stares at you. He also wants you to drink your milk!" or "If you are not drinking your milk, he will."

In both children and adults, what may change is the stability of the relation that is the basis of this process. In some cases, the relation is steady. This is the situation for the relation that a young child has with his or her object of attachment (a teddy bear, soft doll, piece of cloth, blanket, pillow, etc.). Just like adults, children do not attribute mental states to objects on the basis of perceptual similarity to living beings. In one study, children 3 years of age attributed significantly more mental states to their attachment toy than to their favorite toy (Gjersoe et al., 2015). For older children and adults in general, this is the relation that is established with a pet.

In other situations, the relation is momentarily established due to specific circumstances. In this case, the range of possibility is wide. Children, sometimes together with adults, engage in pretend play involving real or imaginary objects and animals. Children and adults anthropomorphize any type of object that may be invited to be more cooperative or blamed for a misdeed, for example.

The model is the same both in the cases of steady relations and temporary ones. The application of the communicative format implies that in both cases, (1) the actor perceives the interlocutor as intentional and (2) the interlocutor's actions are perceived as addressed to the actor (Airenti et al., 1993).

Importantly, this model distinguishes beliefs from anthropomorphic attribution. The anthropomorphic attribution is independent of the possibility that humans entertain anthropomorphic beliefs about animals. This communicative format can always be suspended, and this shows that the anthropomorphic attribution is not based on beliefs. A child may discard without qualms a toy that she previously addressed as a partner in a fantasy game. An adult will drive her or his car without thinking that s/he has previously invited it to behave.

From this perspective, we can reconsider Piaget's point of view regarding young children's animism. According to him, children attribute consciousness and agency to all the entities of the world because they are not able to distinguish their own self from the outside world. Anthropomorphism is then a product of confusion, indissociation in Piaget's terms, and is destined to disappear in adulthood.

In fact, if we adopt the interaction model that we have proposed here to explain anthropomorphism, it clearly appears that young children and adults collocate on a continuum. Young children, just like adults, manifest a human predisposition to involve in a communicative format non-human entities, and their attitude toward anthropomorphism is independent of their beliefs, whether they are true or false.

This perspective better explains the fact that cases of anthropomorphism that are taken as examples of children's confusion are also very common in adults, such as accusing a wall of hurting or blaming the rain because it hinders a planned activity. Importantly, in this view, the first and second phases of children's animism according to Piaget also appear in clear continuity. The second phase is characterized according to Piaget by the process of introjection, defined by him as "the tendency to situate in others or in things the reciprocal feelings to those we experience from their contact" (*ibid.*, p. 242). An illustration of this type of anthropomorphism is the fact that consciousness of pain presupposes the attribution of malice to the object that is source of it. This definition seems incongruous and difficult to explain if we consider that the attribution is the product of a belief. If we consider it from a relational point of view, it becomes very easily understandable. Reciprocity, in fact, is a basic feature of interactions (Airenti, 2010). Interlocutors expect that there is a reciprocal relation between their actions. Thus, one possible human means to react to a fact caused by a non-human is to personify the non-human and put it in the position of addressee in an interaction. This is not simply animism but rather anthropomorphism because in this case, attributing the role of interlocutor to a non-human entity implies the ascription of mental and affective states. If someone hurts her finger and blames the cause of it, it is the same if it is a door that closed unexpectedly or a pup's biting. Beliefs about the intentionality of doors and pups are not in question. It is the position in a relation that implies the attribution. Thus, young children, older children and adults may have different beliefs about non-human entities, but in these situations, they react in a similar manner. At the same time, under different circumstances, young children, like adults, may behave toward the same non-human entities in a non-anthropomorphic, realistic manner.

## CONCLUSION

In this article, I have discussed the cognitive processes underlying anthropomorphism.

Some authors have proposed that the attribution of human mental states and emotions to non-human entities is based on the same brain mechanisms that humans have developed to understand other humans (see Urquiza-Haas and Kotrschal, 2015, for a review). All stimuli indicating animacy would automatically activate the social network in the brain. This process, according to Urquiza-Haas and Kotrschal (2015), combines with domain-general mechanisms such as inductive and causal reasoning more influenced by cultural differences and individual variability.

My hypothesis is that a crucial distinction has to be drawn between anthropomorphic beliefs and anthropomorphic interactions. The major tenet of my argument is that anthropomorphism is not grounded in specific belief systems but rather in a specific modality of interaction. In interaction, a non-human entity takes the place that is generally attributed to a human interlocutor.[6] This process means that anthropomorphism is independent of the beliefs that people may have about the nature and features of the entities that are anthropomorphized. This perspective allows us to explain problems that emerge if we consider anthropomorphism as a belief: (i) adults under certain circumstances may anthropomorphize entities even if they perfectly know that they have no mental life; (ii) according to the situation, the same entity may be anthropomorphized or treated as an object; (iii) there is no consistency among the entities that are anthropomorphized; and (iv) there is individual variability in anthropomorphization, and the variability derives from affective states rather than from different degrees of knowledge about the entity that is anthropomorphized or greater or lesser naivety of the person who anthropomorphizes.

In the process of anthropomorphization, an imaginary dialogue is established with an entity. This format implies the attribution of mental and affective states. I argue that this format is the basis of any form of anthropomorphism. This format is activated any time a human relates with a non-human entity. What may change are the motivations that induce a human to establish a relation with an object, an event or a biological entity; the type of relation; and the complexity of mentality that is attributed. It is at this level that cultural differences are relevant. For instance, this process may influence the relationship that is normally accepted with animals. In Europe or in the United States, cats are typical house pets and are considered ideal companions, whereas in Korea, they are not accepted in this role. There is also space for individual variability. Even in a society that appreciates the value of the companionship offered by pets, the strength of the bond that individuals establish with them varies and with this the complexity of the attributed mentality, such as the attribution of secondary emotions, also varies.

From this perspective, it is also easier to understand anthropomorphism in children. Children very precociously acquire the communicative format that allows for anthropomorphization. Thus, they may apply it in the same manner that adults do. In this sense, there is no difference from adults. There is no reason to postulate a specific animistic form of thinking that would characterize only children and for which there is no evidence.

If we separate the activation of anthropomorphic attribution from the beliefs about non-human entities, the obvious fact that children's knowledge about these entities is not as developed as adults' knowledge is irrelevant. In fact, what appears when we question children about their beliefs is their limited knowledge and not an underdeveloped form of thinking. Possible differences only concern those aspects that affect variability among adults, i.e., the motivations, types of relations, and mentality attributed to non-human entities. These aspects are age-related. In particular this is true for the attribution of mental and affective states. In anthropomorphic attribution, children use the same theory of mind abilities that they use in interactions with humans and that correspond to their stages of development.

In conclusion, precociously acquired communicative and imaginative abilities will enable even young children to extend to non-humans the interaction format that they use in their everyday relations. Regarding the attribution of mentality, its complexity will depend on the current development of the theory of mind (Airenti, 2015a, 2016).

This approach is also useful to explain how adults and children influence each other in the anthropomorphic process that develops in their interactions. Though human predisposition toward anthropomorphism already manifests in infants, its use is so present in children because it is strongly supported by adults. Adults who are normally scarcely aware of their own use of anthropomorphism explicitly use it in their interactions with young children. They both encourage pretend play and storytelling in which non-humans – including not only animals but also other biological entities such as plants or objects – are anthropomorphized. The intent is often explicitly pedagogical. In this manner, children are supposed to acquire knowledge and social and moral rules. The underlying idea is that learning through, for instance, animal stories should be more natural and simpler for children. Actually, this belief is contradicted by experimental research. A number of studies have shown that children enjoy listening to stories but that learning is not favored by the presence of anthropomorphic characters. In fact, children are more likely to transfer to the real world knowledge derived from realistic stories than that from anthropomorphic stories

[6]A relation between anthropomorphism and communication has been proposed by Horowitz and Bekoff (2007) who suggest that anthropomorphization could occur when animals' behavior follows the rules of human communication.

(Larsen et al., 2018). Thus, the fact that anthropomorphism is a fundamental tool for children's learning appears to be an adult bias. This topic is still understudied: clarifying adults' vision of children's anthropomorphism would be very useful to better understand anthropomorphism in general. Intuitively, one could say that adults anthropomorphize infants in the same manner that they do pets. When adults interact with infants, they attribute to them a theory of mind as complex as theirs. At the same time, adults constantly lead children toward anthropomorphism. All of these matters should be further explored. What is certain is that adults' and children's anthropomorphism are intertwined and that it is not possible to discuss children's anthropomorphism without considering adults' folk psychology about children.

In conclusion, in this article, I argued that anthropomorphism is not a form of belief but rather a means to establish a relation with non-humans as if they were human beings. Anthropomorphism is a basic human attitude that begins in infants and persists throughout life. The difference between adults and children is a matter of the growing complexity of the same mental processes.

## AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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# Imagining Others' Minds: The Positive Relation Between Children's Role Play and Anthropomorphism

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Children's role playing, whether personifying toys or imagining invisible friends, involves imagining others' minds and internal states. Similarly, anthropomorphism – the attribution of internal states to non-human others (e.g., animals, inanimate nature, or technologies) – also involves imagining others' minds and internal states. We propose that the imaginative process of simulating and projecting internal states is common to both role play and anthropomorphism. The current study investigated the relation between children's role play and anthropomorphism. Ninety children (5, 7, and 9 years) were administered Individual Differences in Anthropomorphism Questionnaire – Child Form (IDAQ-CF), comprised of the technology-inanimate nature and animal subscales, and the Role Play Scale, which assessed (a) impersonation of animals, people, and/or machines and (b) imaginary companions (ICs), including invisible friends and personified toys. Results indicated that the imaginative act of impersonating an animal, person, and/or machine was positively related to anthropomorphism, and specifically anthropomorphism of inanimate nature and technology. Second, anthropomorphism of animals was highest amongst children with invisible ICs, followed by those with toy ICs and those who impersonated. Finally, children who frequently engaged with an invisible ICs more readily anthropomorphized in general and technology and inanimate nature in particular relative to all other children. Results are discussed in terms of the differing degrees of imagination involved in anthropomorphism of animals versus technology and inanimate nature.

**Keywords: anthropomorphism, pretense, role play, imagination, children, simulation theory**



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## INTRODUCTION

*"...if she brought home a flower, or a pebble she always brought several flowers or pebbles at the same time so they should have company and not feel lonely" (Piaget, 1929, p. 209).*

Young children often endow inanimate objects with a range of internal states (e.g., emotions, thought, and desires) and these attributions, as the above quote illustrates, can guide children's behavior. Piaget's (1929) seminal work on animism – children's tendency to attribute consciousness and life to inanimate objects – provided detailed observations and a theoretical framework to explain this tendency and, in turn, inspired decades of developmental research to uncover the nature of children's conceptions (e.g., Gelman and Spelke, 1981; Carey, 1985; Gelman, 2003; Inagaki and Hatano, 2006). This corpus of work has shown that, contrary to Piaget's assertion, young children (by age 3) are quite capable of distinguishing between animates and inanimates in terms of movement (Gelman and Gottfried, 1996), biology (Gelman, 2003), and psychological properties (Gelman and Spelke, 1981). And yet this explanation seemingly fails to account for children's widespread tendency to attribute human-like mental states to inanimate entities, what is often referred to as anthropomorphism (Waytz et al., 2010a; Severson and Lemm, 2016). That is, if young children distinguish between animates and inanimates (for example, understanding that rocks are inanimate while dogs are animate), how do we understand the numerous instances in which this distinction appears to be blurred, such as when the child brings home several rocks or flowers so that none are lonely?

One possibility is that children are pretending. Consider, for example, children's propensity to personify toys and stuffed animals. It seems reasonable that children may not be sincere in their attributions of internal states and personalities to such artifacts. In fact, Gelman et al. (1983) suggested that children were rarely animistic *except* when they were induced to answer in "play mode." Yet, is it the case that children attribute internal states to inanimate entities *only* in the context of pretense? Or might their attributions reflect their veridical beliefs? Piaget (1929) viewed animism in the context of play as a separate endeavor (and, indeed, deferred discussion of it in his treatise on animism, p. 207). Moreover, there is evidence that children can be quite sincere (i.e., not in play mode) when attributing animate characteristics to objects (e.g., Kahn et al., 2006), and in particular when they are attributing *psychological* characteristics (Waytz et al., 2010a; Severson and Lemm, 2016). In short, children ascribe internal states to objects in the context of pretense, but they also make those assertions quite seriously (i.e., anthropomorphism). Thus, it is important to understand anthropomorphism as a pervasive phenomenon that goes beyond mere pretense.

Although we argue that pretense and anthropomorphism are distinct, they nevertheless appear to involve conceptually related processes. Children's anthropomorphism – the attribution of internal states to non-human others (e.g., animals, inanimate nature, or technologies) – involves imagining others' minds and internal states. Similarly, pretense, whether personifying toys or imagining invisible friends (i.e., role play), also involves imagining others' minds and internal states. Thus, it may be that the process of imagining others' internal states is common to both anthropomorphism and pretend role play. The current study seeks to investigate the relation between anthropomorphism and pretend role play in children 5, 7, and 9 years as a starting point toward understanding whether both might draw upon a common imaginative process. Although this study does not directly assess the underlying processes in either anthropomorphism or role play, it represents an initial step in establishing whether there is a pattern of association between these phenomena.

## Role Play

Pretend play is a hallmark of childhood. Children pretend to be a favorite character or fierce animal, they endow stuffed animals with elaborate personalities, and even create entirely imagined companions that can have an appreciable presence despite being invisible (e.g., a place setting at the table; Taylor and Carlson, 2002). Collectively referred to as 'role play,' these forms of pretense include impersonation of other people, animals, or machines, as well as creation of imaginary companions (ICs), whether a stuffed animal, toy, or an invisible friend (Harris, 2000). In this way, role play is distinct from solitary or joint pretend play involving object substitution (e.g., substituting a banana for a phone) (Taylor and Carlson, 1997; Harris, 2000).

According to Simulation Theory, role play is thought to involve a dual process of simulation and projection (Harris, 2000). That is, children imagine (or simulate) internal states (e.g., perspectives, emotions, thoughts) and project those internal states onto either themselves (in the case of impersonation) or an IC, whether a stuffed animal or an invisible friend. Further, Harris (2000) argues that role play and theory of mind are conceptually related, as both involve simulation of mental states, and only the target of the simulation differs (e.g., an imaginary friend in the case of role play and a person in the case of theory of mind). Perhaps not surprisingly then, children who have invisible ICs tend to perform better on standard measures of theory of mind (Taylor and Carlson, 1997) and have better mental representation abilities (Taylor et al., 1993). In other words, imagining others' minds – whether pretend others (role play) or human others (theory of mind) – is positively related.

Role play is quite prevalent in childhood. Nearly all children (95–100%) engage in impersonation and do so at the same rate from preschool (3–4 years) to early school age (6–7 years) (Taylor and Carlson, 1997; Taylor et al., 2004), with boys showing higher rates of impersonation (Carlson and Taylor, 2005). Further, roughly two-thirds of children (age 3–7 years) have an IC (toy or invisible) although the type of ICs children create changes with age (Taylor et al., 2004). Taylor et al. (2004) found that preschoolers were equally divided between invisible friends (48%) and personified toys (52%), whereas 6- and 7-year-olds were more likely (67%) to have invisible friends than personified toys (33%). The prevalence of ICs declines markedly by age 9 and beyond, with approximately one-third of 9-year-olds and only 9% of 12-year-olds reporting having an invisible IC (Pearson et al., 2001). Moreover, children vary in the frequency with which they engage in the different forms of role play. For example, Carlson and Taylor (2005) found that roughly half of the 3- and 4-year-olds in their study reported having an invisible companion and the majority reported impersonating. However, when considering the frequency with which children engaged in these forms of role play (based on parent-report), the prevalence reduced considerably when limited to frequent pretenders (28% for those with ICs, 19% for impersonators). Thus, children's level of engagement in terms of frequency has been an important criterion to distinguish children who are high versus low in role play (e.g., Taylor and Carlson, 1997; Carlson and Taylor, 2005). And this distinction is meaningful. For example, the positive association with theory of mind was found in those children who frequently engaged in role play (Taylor and Carlson, 1997).

It is also the case that the forms of role play are uniquely related to individual differences in social cognitive and imaginative abilities. As mentioned previously, preschool children with invisible ICs have more advanced theory of mind and mental representation abilities (Taylor et al., 1993; Taylor and Carlson, 1997). Children with invisible ICs may have greater imaginative abilities due in part to the fact that their ICs are completely imaginary, rather than relying upon a physical toy that often provides some suggestions of persona or a character or persona that a child embodies. Indeed, relative to their counterparts who endow stuffed animals or toys with elaborate personalities, children with invisible ICs have advanced visual imagery abilities (Tahiroglu et al., 2011). On the other hand, 6- and 7-year-olds who readily impersonated other people and characters (compared to those who do not) demonstrated better emotional understanding, yet 6- and 7-year-olds with ICs showed no advantage in emotional understanding (despite the previous relation as preschoolers) (Taylor et al., 2004). In short, although the forms of role play are theorized to involve a common process of mental simulation, there is evidence that the role play types may be differentially associated with certain cognitive abilities. As a result, and as others have argued (e.g., Harris, 2000; Carlson and Taylor, 2005), the forms of role play should be considered separately.

## Anthropomorphism

Anthropomorphism also involves imagining others' minds. At its core, anthropomorphism refers to the attribution of humanlike minds and internal states to non-humans (Epley et al., 2007; Severson and Lemm, 2016), although some also conceptualize anthropomorphism as including attributions of humanlike physical features (e.g., Guthrie, 1993; Barrett and Richert, 2003; see Waytz et al., 2010a for an overview). In the act of anthropomorphizing, people may ascribe humanlike emotions, beliefs, desires, knowledge, intentions, sociality, and moral worth and responsibility to non-human entities (Epley et al., 2007; Severson and Carlson, 2010). Importantly, these attributions are independent of biology – that is, children attribute psychological states to technologies while simultaneously judging them as non-biological (e.g., Kahn et al., 2006, 2012; Jipson and Gelman, 2007; Melson et al., 2009) – suggesting that anthropomorphism is related to mentalizing rather than biological concepts.

Not only are the features one may attribute when anthropomorphizing quite broad, the targets are also widely varied. Humans anthropomorphize animals, inanimate nature, natural phenomena, supernatural entities, illnesses, objects, and technologies (e.g., Chin et al., 2005; Waytz et al., 2010a; Shahar and Lerman, 2012). Additionally, Guthrie (1993) theorizes that anthropomorphism is a universal human tendency (see also Zawieska et al., 2012). This notion is substantiated by the high prevalence of anthropomorphism among children and adults (Bloom, 2007; Waytz et al., 2010a; Severson and Lemm, 2016), and the fact that it is so far-reaching, both in terms of the subject matter that is anthropomorphized and in the variety of peoples that anthropomorphize (Epley et al., 2007).

Although anthropomorphism is often conceptualized as a unified construct, it is important to note that critical distinctions exists depending upon the class of non-human entities. First, anthropomorphism of animals, technology, and inanimate nature is independent from the anthropomorphism of supernatural (or spiritual) entities (Waytz et al., 2010a, Study 1; Willard and Norenzayan, 2013). Second, anthropomorphism of animals is distinct from anthropomorphism of inanimate nature and technology (although they are correlated), and both children and adults anthropomorphize animals to a greater degree than inanimate nature and technology (Waytz et al., 2010a, Study 2; Severson and Lemm, 2016; Li et al., 2017).

Why then do people anthropomorphize? Several non-mutually exclusive explanations have been put forth to explain this common human tendency. Broadly speaking, anthropomorphism may result from internal (human) motivations, overextension of cognitive mechanisms, or external (entity) factors. First, individuals anthropomorphize in order to fill in gaps in their knowledge of non-human entities. Indeed, individuals are more likely to anthropomorphize qualities of non-human entities that are not readily observed, such as internal states (Epley et al., 2007). Barrett and Richert (2003) likewise suggest that, when necessary, people anthropomorphize in order to "fill in the blanks" in their cognition. For example, because it is not possible to fully comprehend the experiences of our pets, people default to what they know best – their own emotional experience. That is, individuals often extend to their pet the same complex human emotions a person would experience when they are left alone for a long period of time or separated from their birth families as puppies. The anthropomorphism that occurs in these situations is likely due to the basic human motivation to understand one's environment and possess some degree of agency over it. Anthropomorphism fulfills these basic human desires by making non-human entities appear similar to oneself and thus reduces the "uncertainty, unpredictability, and randomness" that results from a sense of low agency (Waytz et al., 2010b, p. 424).

Second, it is also possible that anthropomorphism results from an overextension of one's social cognition (e.g., Boyer, 2001). In typical circumstances, adults and children utilize their theory of mind to conceptualize and make predictions regarding other individuals' internal states. Yet, children (and adults) may apply their reasoning about others' minds more broadly. That is, children may use their theory of mind to seek to understand non-human others' actions and internal states. Indeed, during the preschool period in which theory of mind development is most marked, children more readily anthropomorphize non-human entities (Tahiroglu, 2012). It stands to reason that children encounter difficulties in determining which entities have internal states and how human-like their internal states may be. In this way, the overextension of social cognition is related to filling in the gaps in one's knowledge (discussed above). What follows is that children overgeneralize their developing theory of mind and endow animals and other non-human entities with internal states similar to their own. In fact, research suggests that infants attribute minds to anything that exhibits self-propelled movement and behavior that follows a stimulus from the environment (e.g., Gergely et al., 1995; Csibra et al., 1999).

Third, external factors particular to the entity being anthropomorphized may contribute to one's tendency to anthropomorphize. For example, certain entities provide external or behavioral cues that are suggestive of internal states. Waytz et al. (2013) have termed these 'target triggers.'

Animals display various behaviors that are readily interpreted as indicative of their emotions. A wagging tail indicates happiness. A nip indicates anger or annoyance. Even the addition of eyes to simple shapes (e.g., circles or spheres) is enough to suggest internal states to infants (e.g., Johnson et al., 1998; Hamlin et al., 2007). Entities with robust or numerous external mental states cues are more readily anthropomorphized than those with comparatively weak or few target triggers, as evidenced by the higher rates of anthropomorphism of animals compared to technology and inanimate nature (e.g., Waytz et al., 2010a; Severson and Lemm, 2016). Indeed, it may be that entities that lack external cues of agency and mental states require more motivation or imagination on the part of the individual to view such entities in anthropomorphic terms. Thus, the tendency to anthropomorphize may be due to factors within an individual (e.g., filling in the gaps in their knowledge or overextension of social cognition) or to features or behaviors of the entity that is the target of anthropomorphism (e.g., eyes or a wagging tail), or a combination of both.

Although anthropomorphic beliefs are relatively stable in adulthood (Waytz et al., 2010a), there is evidence that anthropomorphic beliefs undergo developmental changes. However, the early evidence is somewhat mixed in terms of the specific trajectory. Some studies have found age-related increases in anthropomorphism. For example, 5-year-olds and adults were more likely than 3- and 4-year-olds to perceive internal states in Heider and Simmel's (1944) movie of animated shapes (Springer et al., 1996). In other work, 4- and 6-year-olds did not differ in anthropomorphism of animals (Li et al., 2017), yet 9-year-olds were more likely than 5-year-olds to anthropomorphize animals (Severson and Lemm, 2016). Taking these studies together, 5-year-olds appear quite adult-like when using movement as a cue to infer internal states to simple geometric shapes, and further age-related changes are evident between 5 and 9 years when endorsing anthropomorphic beliefs about animals. Still, other studies show no significant age-related changes in anthropomorphism of technology and inanimate nature between 4- and 6-year-olds (Li et al., 2017) or 5-, 7-, and 9-year-olds (Severson and Lemm, 2016), although descriptively younger children endorsed more anthropomorphic beliefs about technology and inanimate nature. The effect sizes in these studies were small to medium (Cohen's $d$ ranged from 0.29 to 0.55) suggesting they may have been underpowered to detect these effects (although note that age-related effects were not the primary goal of either study). Thus, the research suggests there are differing developmental trajectories for anthropomorphism of animals versus inanimate nature and technology.

## Theoretical Implications of a Relation Between Role Play and Anthropomorphism

Why might a relation between role play and anthropomorphism be of interest? We suggest there are important theoretical implications for such a relation. According to Simulation Theory (Harris, 2000), the imaginative process of simulating and projecting internal states is theorized to be involved in both role play and social cognition. Building on this idea, we further suggest that anthropomorphism may draw upon the same imaginative process. Indeed, it may be the case that the simulation process is common to mentalizing more generally, whether imagining the internal states of another person (social cognition), a non-human entity (anthropomorphism), or an imaginary friend (role play). Although the underlying cognitive process may be similar, it follows that separate additional processes would also be involved, for example, the self-other distinction in social cognition, the fantasy-reality distinction in role play, and the animate–inanimate distinction in anthropomorphism.

In line with this reasoning, several studies suggest a relation between social cognition, role play, and anthropomorphism. Tahiroglu (2012) found a positive relation between role play and anthropomorphism in both adults and children (4–6 years). Moreover, Castelli et al. (2000, 2002) found neural activation of the 'mentalizing' network in response to anthropomorphized animated shapes, although this pattern of activation was not evident among adults with autism (Castelli et al., 2002). Yet, research using other measures have produced mixed results. Tahiroglu (2012) found evidence in 4- to 6-year-olds of a relation between false belief understanding (false contents task) and anthropomorphism (using an interview-style measure), but this relation was not significant using other theory of mind measures and a narrative measure of anthropomorphism of animated shapes (akin to the procedure used by Castelli et al., 2000). Recent work suggests that adults with autism personify objects at higher rates than non-autistic adults (White and Remington, 2018) – a result that is striking given the typical deficits in theory of mind among individuals with autism (see also Atherton and Cross, 2018).

The mixed results point to the need for further investigation into the potential relation between social cognition, role play, and anthropomorphism. Answers to these questions could have important implications for our understanding of each of these constructs, individually as well as how they may relate to each other. It is therefore of theoretical interest to explore the bounds of simulating others' minds (i.e., whether this imaginative process also explains anthropomorphism). If so, it will be important to understand the nature of the relation (e.g., causally related or based on a common underlying mechanism), how other cognitive processes may uniquely operate within each context (social cognition, role play, and anthropomorphism), and whether any relation holds in atypical populations (e.g., individuals on the autism spectrum).

## The Current Study

Thus, the purpose of the current study was to examine the relation between individual differences in role play and anthropomorphism in children 5, 7, and 9 years old. We focused on this age range as anthropomorphism and role play are prevalent during this period, although with slightly different trajectories and timeframes. Role play is equally prevalent in children from 3 to 7 years and declines by age 9 (Taylor et al., 2004), whereas anthropomorphism (of animals) increases from age 5 to 9 (Severson and Lemm, 2016). Thus, although we had no *a priori* predictions of age-related changes in the relation between role play and anthropomorphism, we sought to assess the relation across a broader age range in order to capture potentially important developmental shifts, particularly as role play decreases and anthropomorphism increases. Importantly, if a positive relation between role play and anthropomorphism exists independent of age, it is reasonable to further consider how they are related and whether they rely upon a common underlying process. Thus, as an initial step in examining the relation between these constructs, it is important to consider whether the relation is temporally bound to a particular age or if it holds across age groups.

Two main questions structured our investigation. First, is there a positive relation between children's engagement in role play and anthropomorphism? To our knowledge, only one previous study (Tahiroglu, 2012) found correlational evidence of such a link in 4- to 6-year-olds, thus we sought to replicate the earlier finding with a broader (and older) age range. Second, we reasoned that higher levels of imagination in role play (i.e., children with invisible ICs and/or high frequency of role play) would be related to forms of anthropomorphism that involve greater imagination (i.e., attributing internal states to inanimate nature and technology). In other words, we posited that the specific link between role play and anthropomorphism is based on individual differences in one's tendency to engage in the simulation process to imagine others' mental states. These individual differences may result from differences in simulation ability, wherein some children are more facile in the simulation process and readily do so across domains (pretense and anthropomorphism). Or individual differences may result from differences in children's experience simulating mental states, such that repetitively engaging in simulation in one domain (pretense) may lead to more simulation in another domain (anthropomorphism, or vice versa). Accordingly, individuals with greater imaginative (i.e., simulation) abilities in role play should show a corresponding proclivity to anthropomorphize, and especially so with entities that provide few to no cues of internal states (e.g., inanimate nature), and thereby placing higher demands on the child's ability to imagine. Thus, the second question asked whether more sophisticated forms of role play differentially relate to anthropomorphic tendencies?

## MATERIALS AND METHODS

### Participants

Participants included 90 children ages 5 ($n$ = 30; $M_{age}$ = 5.5, $SD$ = 0.28; 50% girls), 7 ($n$ = 30; $M_{age}$ = 7.4, $SD$ = 0.32; 50% girls), and 9 ($n$ = 30; $M_{age}$ = 9.4, $SD$ = 0.24; 50% girls) years. The majority of participants were White (73%), with the remaining participants indicating their race/ethnicity as more than one race/ethnicity (18%), Latino/a (3%), Asian (2%), and Other (9%). Participants were recruited through flyers distributed throughout the community and announcements in school newsletters. This study was carried out in accordance with the recommendations of Human Subjects Division of the WWU Research Compliance Office, Institutional Review Board (IRB) Committee. The protocol was approved by the IRB Committee. All parents of participating children gave written informed consent in accordance with the Declaration of Helsinki, and participating children provided assent. Each participant received a t-shirt and $5 for their participation.

### Measures and Procedure

The study was conducted at a university research laboratory in Bellingham, WA, United States. Following the consent/assent process, participants were individually administered the Individual Differences in Anthropomorphism Questionnaire – Child Form (IDAQ-CF) followed by the Role Play Scale. The data for the current study come from a larger study on children's conceptions of a social robot and a puppet, in which we investigated the factor structure and predictive validity of the IDAQ-CF in a child sample (Severson and Lemm, 2016, Study 2). The measures in the current study were the first two administered in the larger study's procedure, and the subsequent measures focused on children's conceptions of a social robot and puppet (e.g., familiarization phase, free play, attribution interview).

#### IDAQ-CF

The IDAQ-CF assesses individual differences in children's anthropomorphism of technologies, inanimate nature, and animals (Severson and Lemm, 2016). The IDAQ-CF was adapted for use with children from the adult version of the IDAQ (Waytz et al., 2010a). Like the adult version, the IDAQ-CF consists of two correlated factors: One assessing anthropomorphic beliefs about technology and nature (Technology-Nature subscale) and the other assessing anthropomorphic beliefs about animals (Animal subscale). We refer the interested reader to Severson and Lemm (2016) for a detailed description of the development and validation of the IDAQ-CF.

Participants were first trained on a two-part question format. The first part consisted of a yes/no question (For example, "Do you like candy/broccoli/carrots?") to which children responded using a 'thumbs up' (yes) or 'thumbs down' (no). 'Yes' responses were followed up with the second part of the question, "How much?" (For example, "How much do you like candy/broccoli/carrots?"), to which children were directed to answer on a scale with three increasingly tall bars labeled "a little bit," "a medium amount," and "a lot." Thus, responses were coded on a 4-point scale: No (0), Yes-a little bit (1), Yes-medium amount (2), and Yes-a lot (3). The 12 IDAQ-CF test items were then presented in random order following this two-part question format (**Table 1**).

#### Role Play Scale

We assessed children's engagement in role play in terms of impersonation and ICs (adapted from Taylor and Carlson, 1997). The impersonation measure included child- and parent-report of the child's impersonation of animals, other people (e.g., parent, doctor, teacher), and/or machines (e.g., car, airplane). That is, across three questions, children were asked if they had ever pretended to be an animal, another person, and/or a machine. Responses received a score of 1 for a "yes" response and 0 for a

**TABLE 1 |** Means (SD) on IDAQ-CF by age group.

| IDAQ-CF items (presented in random order) | | 5 years *M* (*SD*) | 7 years *M* (*SD*) | 9 years *M* (*SD*) |
|---|---|---|---|---|
| Technology-Nature subscale | 1. Does a car do things on purpose? [intention] | 0.63 (1.10) | 0.53 (1.01) | 0.43 (0.86) |
| | 2. Does a TV have feelings, like happy and sad? [emotion] | 0.67 (1.06) | 0.10 (0.55) | 0.27 (0.74) |
| | 3. Does a robot know what it is? [consciousness] | 1.20 (1.22) | 0.93 (1.14) | 0.90 (1.19) |
| | 4. Does computer think for itself? [mind] | 0.97 (1.40) | 0.43 (0.97) | 1.07 (1.34) |
| | 5. Does the wind do things on purpose? [intention] | 1.23 (1.36) | 0.59 (1.09) | 0.60 (1.10) |
| | 6. Does a mountain have feelings, like happy and sad? [emotion] | 0.40 (0.86) | 0.10 (0.40) | 0.40 (0.93) |
| | 7. Does the ocean know what it is? [consciousness] | 0.47 (1.07) | 0.33 (0.84) | 0.37 (0.81) |
| | 8. Does a tree think for itself? [mind] | 0.53 (1.04) | 0.40 (0.89) | 0.57 (1.01) |
| | ***Subscale Mean Score*** | **0.76 (0.79)** | **0.44 (0.45)** | **0.61 (0.52)** |
| Animal subscale | 9. Does a turtle do things on purpose? [intention] | 0.77 (1.07) | 1.41 (1.15) | 1.79 (1.18) |
| | 10. Does a cheetah have feelings, like happy and sad? [emotion] | 2.13 (1.07) | 1.93 (1.05) | 2.27 (0.94) |
| | 11. Does a lizard know what it is? [consciousness] | 0.93 (1.26) | 1.07 (1.03) | 1.57 (1.20) |
| | 12. Does an insect or bug think for itself? [mind] | 1.20 (1.10) | 1.53 (1.07) | 1.90 (1.05) |
| | ***Subscale Mean Score*** | **1.26 (0.79)** | **1.49 (0.72)** | **1.90 (0.80)** |
| | **Overall Mean Score** | **0.93 (0.64)** | **0.79 (0.37)** | **1.04 (0.43)** |

"no" response. Parents were also asked to report whether their child ever pretended to be an animal, a person, and/or a machine and, if so, the frequency in which the child engaged in this type of play (1 = rarely, 5 = frequently).

The IC measure similarly included child- and parent-report of ICs, including toys (e.g., stuffed animals) endowed with a stable personality and completely invisible ICs. Children who reported having an IC (now or in the past) were further interviewed in order to substantiate their claim. These questions probed details about the IC, including its name, age, gender, physical appearance, whether it was a toy or completely invisible (a forced-choice response), and characteristics the child liked or did not like about their IC. Children received a score of '1' if they affirmed (and substantiated) that they had an IC and a score of '0' if they denied having an IC (or affirmed having an IC but did not substantiate their claim). In addition, we categorized children's ICs as 'toy IC' or 'invisible IC' based on their response to the forced-choice question in the IC interview. Across two questions, parents reported whether their child had an IC that was invisible and/or a stuffed animal with a distinct personality, and, if so, the frequency in which the child engaged in this type of play (1 = rarely, 5 = frequently). Children were also administered Singer and Singer's (1981) imaginative play predisposition scale which assesses children's favorite game, favorite toy, and whether they talk to themselves and what they think about prior to falling asleep. Those data have not been coded and are not included in the current analyses.

# RESULTS

We first report the descriptive results of the anthropomorphism and role play measures, followed by analysis of the relation between anthropomorphism and role play. There were no gender differences for our dependent variables (*p*s $> 0.14$), thus subsequent analyses were collapsed across gender. Age differences were tested on all dependent variables and are reported where found.

## Anthropomorphism

Children's scores on the IDAQ-CF were computed by averaging their responses across the eight technology-nature items (Technology-Nature subscale, $\alpha = 0.85$), the four animal items (Animal subscale, $\alpha = 0.71$), as well as across all 12 items (Overall scale, $\alpha = 0.79$). Responses ranged from 0 (no endorsement of anthropomorphic beliefs) to 3 (full endorsement of anthropomorphic beliefs). **Table 1** reports descriptive results by item and subscale for each age group. Children endorsed anthropomorphic beliefs about animals ($M = 1.53$, $SD = 0.80$) at a significantly higher rate than of technology and nature ($M = 0.59$, $SD = 0.60$), $t(89) = -9.45$, $p < 0.001$, $d = 1.34$. Significant age differences were found on the Animal subscale, $F(2,87) = 4.43$, $p = 0.02$. *Post hoc* analyses indicated that 5-year-olds ($M = 1.26$, $SD = 0.79$) endorsed lower levels of anthropomorphic beliefs about animals compared to 9-year-olds ($M = 1.90$, $SD = 0.80$), $p = 0.01$, $d = 0.73$ (see **Table 1**). Although 7-year-olds ($M = 1.49$, $SD = 0.72$) did not differ significantly from either 5- or 9-year-olds (*p*s $> 0.18$), those differences represented small to medium effects ($d = 0.31$ and $d = 0.46$, respectively) in the direction of increased anthropomorphism of animals with age. Although significant age differences were not found on the Technology-Nature subscale ($p = 0.12$), the direction trended towards reduced anthropomorphism of technology and inanimate nature with age. Age differences were not found on the Overall scale ($p = 0.16$). The differing developmental trajectories on the Animal subscale (significant increase with age) versus the Technology-Nature subscale (trending downward with age) underscore the important distinction between the subscales.

## Role Play

As described above, the role play scale included children's and parents' report of the child's impersonation and whether they had an IC. Results are presented for each the impersonation scale and ICs.

### Impersonation

Across three questions, children reported whether they impersonated animals, other people, and/or machines (i.e., pretending to be a cat/doctor/airplane). The vast majority of children (93.3%) reported impersonating at least one of these entities, and 91% of parents corroborated their child's report. Results indicated that 78% of children reported pretending to be an animal, 62% pretended to be another person, and 42% pretended to be a machine. There were no age differences in any of the three forms of impersonation ($p$s $> 0.34$). We computed an Impersonation Score based on children's report on the three questions (impersonation of an animal, another person, and/or machine), thus scores could range from 0 (no impersonation) to 3 (impersonation of all three types of entities). The mean Impersonation Score was 1.82 ($SD = 0.87$), with no age differences, $F(2,87) = 0.58$, $p = 0.944$.

### Imaginary Companions (IC)

Sixty-five children (72.2 %) reported having an IC and substantiated their report with detailed descriptions of their IC during the interview (as described in the method). A 2 (IC type: toy or invisible) × 3 (age group) repeated-measures ANOVA revealed a main effect of IC type, indicating children were more likely to report having a toy IC (51.1%) than an invisible IC (21.1%), $F(1,87) = 12.56$, $p < 0.001$, $\eta^2 = 0.13$. Recall that this was a forced-choice question, thus children had to specify whether their IC was a toy or completely invisible. Largely consistent with children's reports, 86% of parents corroborated their child's report of an IC. There were no main effects of age group, $F(2,87) = 0.22$, $p = 0.81$, nor an interaction effect of IC type and age group, $F(2,87) = 0.62$, $p = 0.54$. The lack of significant age differences in IC type may be an artifact of our role play measure. That is, the IC rates include both current and former ICs. Recall that children were asked about their ICs (now or in the past), however, we did not ask them specify whether they were reporting on a current or former IC. Previous research (Taylor et al., 2004) has shown that *current* IC type differs by age with preschooler's (3–5 years) being equally divided between toy and invisible ICs and 6- to 7-year-olds being twice and likely to have an invisible IC. Had we asked children to only report on current ICs, we may have seen age-related differences akin to Taylor et al. (2004). On the other hand, Pearson et al. (2001) found largely equal numbers of both current and former ICs between 5 and 9 years, and only after age 9 did children's report of current ICs sharply decline. Thus, there are some discrepancies in the literature regarding the nature of age-related changes in IC type.

## Relationship Between Role Play and Anthropomorphism

Although we asked both children and parents about the child's role play, we opted to use the child report, at times in conjunction with parent report where noted, in subsequent analyses of the relation between role play and anthropomorphism. This decision was guided by two reasons. First, as reported above, there was a high rate of parent corroboration (86% for ICs and 91% for impersonation) of child-reported role play. Second, as others have argued (e.g., Taylor et al., 2004), parent report alone is often incomplete as parents may not be fully aware of their children's role play, especially with ICs in older children. Regarding the second point, we tested for age differences in parent-report of impersonation and ICs amongst those children who reported role play. Although we found no age differences in parent-report of impersonation ($p = 0.42$), we found marginally significant age differences in parent-report of ICs [$F(2,61) = 2.97$, $p = 0.06$] with 9-year-olds having the lowest rate of parent-report (76%). Thus, these results suggest that parents of 9-year-olds may be comparatively less informed about their children's ICs.

We first examined the relation between impersonation and anthropomorphism. To do so, we used the computed Impersonation Scores, as a comprehensive measure of impersonation, to assess whether impersonation was predictive of anthropomorphism. Impersonation Scores were positively predictive of IDAQ-CF scores, after controlling for any effects of age, for both the overall scale ($\beta = 0.28$, $t = 2.731$, $p = 0.008$) and the Technology-Nature subscale ($\beta = 0.24$, $t = 2.276$, $p = 0.025$), but impersonation scores were only marginally predictive of the Animal subscale ($\beta = 0.182$, $t = 1.809$ $p = 0.07$, power = 0.801). In summary, overall impersonation of animals, people, and/or machines was positively related to the attribution of internal states to non-human entities, and in particular to inanimate nature and technology.

To further explore the relation between impersonation and anthropomorphism, we tested for differences between children who engaged or did not engage in the specific form of impersonation (animal or machine) on the corresponding form of anthropomorphism. No significant differences emerged. That is, children who impersonated animals were no different than those who did not in their anthropomorphism on the Animal subscale ($p = 0.10$, $d = 0.42$), nor did differences emerge on the overall scale ($p = 0.07$, $d = 0.49$) or Technology-Nature subscale ($p = 0.25$, $d = 0.32$). Similarly, those who impersonated machines did not differ from those who did not impersonate machines on the Technology-Nature subscale ($p = 0.21$, $d = 0.27$), nor did differences emerge on the overall scale ($p = 0.25$, $d = 0.24$) or Animal subscale ($p = 0.81$, $d = 0.05$). However, given that the effect sizes were very small to medium, these null results were likely a result of low power, as confirmed by a *post hoc* power analysis using G*Power (Faul et al., 2007) indicating power ranged from 0.06 to 0.48. We also examined differences between children who impersonated people ($n = 56$) and those who did not ($n = 34$) and found significant differences in overall anthropomorphism ($p = 0.05$, $d = 0.42$), with impersonators anthropomorphizing more than non-impersonators. However, there were no significant differences between people impersonators and non-impersonators in animal anthropomorphism ($p = 0.25$, $d = 0.25$) or technology-nature anthropomorphism ($p = 0.09$, $d = 0.38$).

Given our prediction that higher levels of imagination should be related to a greater tendency to anthropomorphize, we then tested whether engagement in role play by role play type was differentially related to anthropomorphism. There is compelling evidence that the forms of role play are quite similar. Indeed, impersonation and ICs (toy and invisible) are both theorized to involve mental simulation (Harris, 2000) and both are related to theory of mind abilities albeit at different ages (Taylor and Carlson, 1997; Taylor et al., 2004). Yet, there is also evidence that role play types vary in important ways. For example, invisible ICs may procure additional benefits in imaginative abilities (e.g., Tahiroglu et al., 2011).

As a first step, we classified children into one of three categories: impersonation only, toy IC, or invisible IC (**Table 2**). We then conducted one-way ANCOVAs to test for differences in anthropomorphism (analyzed using both the two subscales and the full scale) based on role play type while controlling for age. After controlling for potential age effects (*ns*), results indicated significant differences in role play type on the technology-nature subscale, $F(2,83) = 4.215$, $p = 0.02$, as well as the full scale, $F(2,83) = 3.267$, $p = 0.04$. As shown in **Figure 1**, subsequent pairwise comparisons indicated children with invisible ICs anthropomorphized technology and inanimate nature to a greater extent than those with toy ICs ($p = 0.007$), but did not differ from those children who only impersonated ($p = 0.11$). Similarly, on the overall scale, children with invisible ICs anthropomorphized more than children with toy ICs ($p = 0.01$), yet did not differ significantly from children who only impersonate ($p = 0.06$). Conversely, after controlling for significant age effects ($p = 0.004$), we did not find significant group differences on the animal subscale, $F(2,83) = 1.449$, $p = 0.08$, observed power = 0.51). However, the sample size was underpowered to detect the effects observed between children with toy or invisible ICs and those who only impersonated ($d = 0.52$ and $d = 0.78$, respectively).

Children also vary in the frequency with which they engage in the differing forms of role play, and is a marker of their engagement in role play. We were interested in examining direct effects of children's frequency of engagement in role play on anthropomorphism, in addition to the interaction between frequency and role play type. To do so, we used standardized parent-reported frequency ratings (1 = rarely, 5 = frequently; $M = 3.04$, $SD = 1.83$) for each participant based on their role play category (impersonation only, toy IC, or invisible IC), as described above. Simple scatterplots suggested the relation may be curvilinear on the Technology-Nature subscale and overall scale, thus we examined both linear and curvilinear relations

**TABLE 2** | Proportions of role play type by age.

| | Impersonation only | Imaginary companions | |
|---|---|---|---|
| | | Toy | Invisible |
| 5 years ($n$ = 30) | 0.30 ($n$ = 9) | 0.53 ($n$ = 16) | 0.17 ($n$ = 5) |
| 7 years ($n$ = 29) | 0.28 ($n$ = 8) | 0.45 ($n$ = 13) | 0.28 ($n$ = 8) |
| 9 years ($n$ = 28) | 0.18 ($n$ = 5) | 0.61 ($n$ = 17) | 0.21 ($n$ = 6) |
| Total | 0.25 ($n$ = 22) | 0.53 ($n$ = 46) | 0.22 ($n$ = 19) |

*Three children (one 7-year-old and two 9-year-olds) reported not engaging in any of these forms of role play, thus were excluded from these role play categories.*

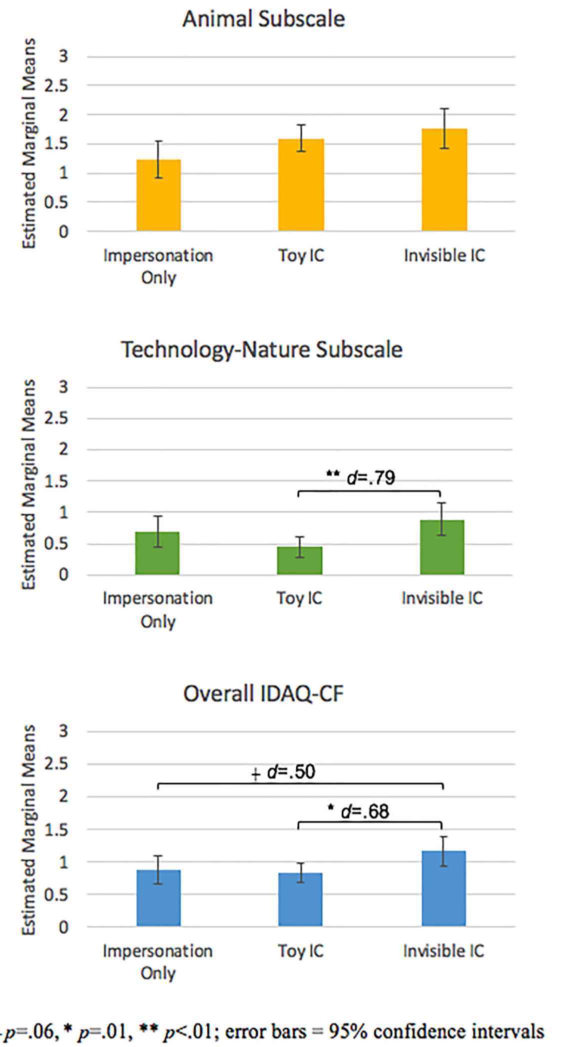



**FIGURE 1** | Mean IDAQ-CF scores by role play type.

between role play frequency on both subscales and the overall scale as moderated by role play type (Dawson, 2014). To do so, we first dummy coded role play type using invisible ICs as the referent category to test for differences with toy ICs (Moderator 1 categorical variable) and impersonators (Moderator 2 categorical variable). We then ran a linear regression in Step 1 and curvilinear (quadratic) regression in Step 2 in order to test for model significance at each step (**Table 3**).

For the Technology-Nature subscale, the curvilinear (quadratic) model (Model 2) produced a significant increase in fit, $F(6,78) = 3.28$, $p = 0.03$, $R^2 = 0.24$ (**Table 3**). A significant curvilinear relation between role play frequency and anthropomorphism of technology and inanimate nature was found (Model 2: Frequency$^2$, $p = 0.02$). This curvilinear relation was moderated by role play type when comparing children with invisible ICs to children who impersonated (Model 2: Freq.$^2$ * Mod. 2, $p = 0.007$), but not when compared to those with toy ICs (Model 2: Freq.$^2$ * Mod. 1, $p = 0.17$).

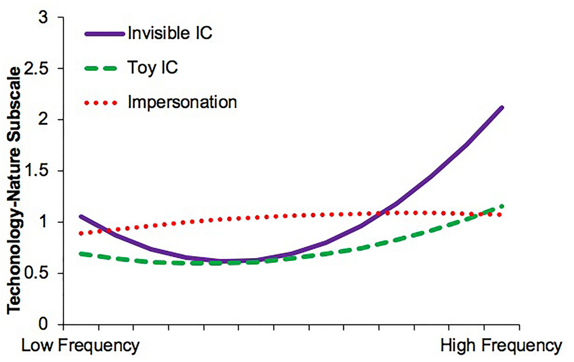
**TABLE 3 |** Hierarchical linear and curvilinear (quadratic) regression analyses predicting anthropomorphism from frequency of engagement in role play and role play type.

| Predictors | Model 1: Linear | | Model 2: Quadratic | |
|---|---|---|---|---|
| | ***b*** **[0.95 CI]** | ***p*** | ***b*** **[0.95 CI]** | ***p*** |
| **Technology-Nature subscale** | | | | |
| | Total $R^2$ = 0.14, $\Delta R^2$ = 0.14, $p$ = 0.06 | | **Total $R^2$ = 0.24, $\Delta R^2$ = 0.10, $p$ = 0.03** | |
| Constant | 1.19 [0.59, 1.80] | <0.001 | 0.69 [0.001, 1.39] | 0.05 |
| Age (control) | −0.05 [-0.12, 0.03] | 0.23 | −0.05 [−0.13, 0.03] | 0.20 |
| Frequency | 0.15 [−0.09, 0.38] | 0.22 | **0.36 [0.08, 0.64]** | **0.01** |
| Frequency$^2$ | – | – | **0.41 [0.07, 0.74]** | **0.02** |
| Moderator 1 | **−0.43 [−0.75, −0.12]** | **0.008** | −0.05 [−0.61, 0.50] | 0.86 |
| Moderator 2 | −0.17 [−0.52, 0.19] | 0.36 | 0.54 [−0.06, 1.14] | 0.08 |
| Freq. × Mod. 1 | −0.06 [−0.36, 0.23] | 0.68 | −0.20 [−0.55, 0.15] | 0.26 |
| Freq. × Mod. 2 | −0.15 [−0.51, 0.22] | 0.43 | **−0.43 [−0.83, −0.03]** | **0.03** |
| Freq.$^2$ × Mod. 1 | – | – | −0.27 [−0.66, 0.12] | 0.17 |
| Freq.$^2$ × Mod. 2 | – | – | **−0.64 [−1.10, −0.18]** | **0.007** |
| **Animal subscale** | | | | |
| | **Total $R^2$ = 0.17, $\Delta R^2$ = 0.17, $p$ = 0.03** | | Total $R^2$ = 0.21, $\Delta R^2$ = 0.07, $p$ = 0.10 | |
| Constant | 0.67 [−0.16, 1.50] | 0.11 | 0.45 [−0.51, 1.41] | 0.36 |
| Age (control) | **0.16 [0.05, 0.26]** | **0.005** | **0.14 [0.03, 0.24]** | **0.01** |
| Frequency | 0.14 [−0.19, 0.46] | 0.41 | 0.28 [−0.12, 0.67] | 0.17 |
| Frequency$^2$ | – | – | 0.29 [−0.17, 0.75] | 0.21 |
| Moderator 1 | −0.15 [−0.58, 0.28] | 0.48 | 0.48 [−0.30, 1.25] | 0.22 |
| Moderator 2 | **−0.52 [−1.01, −0.03]** | **0.04** | 0.05 [−0.79, 0.89] | 0.90 |
| Freq. × Mod. 1 | −0.10 [−0.51, 0.30] | 0.61 | −0.39 [−0.88, 0.09] | 0.11 |
| Freq. × Mod. 2 | −0.13 [−0.63, 0.36] | 0.59 | −0.34 [−0.89, 0.22] | 0.23 |
| Freq.$^2$ × Mod. 1 | – | – | **−0.56 [−1.11, −0.02]** | **0.04** |
| Freq.$^2$ × Mod. 2 | – | – | −0.55 [−1.19, 0.10] | 0.10 |
| **Overall scale** | | | | |
| | Total $R^2$ = 0.09, $\Delta R^2$ = 0.09, $p$ = 0.26 | | **Total $R^2$ = 0.19, $\Delta R^2$ = 0.10, $p$ = 0.04** | |
| Constant | 1.01 [0.49, 1.54] | <0.001 | 0.62 [0.49, 1.54] | <0.001 |
| Age (control) | 0.02 [−0.05, 0.09] | 0.57 | 0.01 [−0.06, 0.08] | 0.74 |
| Frequency | 0.13 [−0.07, 0.34] | 0.20 | **0.32 [0.07, 0.56]** | **0.01** |
| Frequency$^2$ | – | – | **0.36 [0.07, 0.65]** | **0.02** |
| Moderator 1 | **−0.33 [−0.60, −0.06]** | **0.02** | 0.13 [−0.35, 0.61] | 0.60 |
| Moderator 2 | −0.27 [−0.58, 0.04] | 0.09 | 0.38 [−0.15, 0.90] | 0.15 |
| Freq. × Mod. 1 | −0.07 [−0.32, 0.19] | 0.60 | −0.25 [−0.55, 0.05] | 0.10 |
| Freq. × Mod. 2 | −0.13 [−0.44, 0.19] | 0.42 | **−0.38 [−0.73, −0.04]** | **0.03** |
| Freq.$^2$ × Mod. 1 | – | – | **−0.36 [−0.70, −0.02]** | **0.04** |
| Freq.$^2$ × Mod. 2 | – | – | **−0.60 [−1.00, −0.20]** | **0.004** |

*The categorical moderator role play type was dummy coded with invisible IC as the referent, such that Moderator 1 = toy IC vs. invisible IC and Moderator 2 = impersonators vs. invisible IC. Bolded values indicate the best fitting model (linear or quadratic) for the subscales and overall scale, as well as significant predictors ($p$ < 0.05) within each model.*

As invisible ICs was the reference category, children with toy ICs and those who impersonated were not directly compared. Evidence of the curvilinear relation between role play frequency and anthropomorphism of technology and inanimate nature moderated by role play type is illustrated in **Figure 2**. We then tested whether a linear or curvilinear (quadratic) association was significant for each type of role play. For children with invisible ICs, the curvilinear relation between role play frequency and technology-nature anthropomorphism was significant, $b$ = 0.12 [0.003, 0.23], $t(2,15)$ = 2.20, $p$ = 0.04, characterized by a concave (U-shaped) relation with a slight negative association when role play frequency was low and a stronger positive association as role play frequency increased from moderate to high. For children with toy ICs, the modest curvilinear relation was significant, $b$ = 0.05 [0.003, 0.09], $t(2,42)$ = 2.15, $p$ = 0.04, characterized by a slightly positive association between frequency and technology-nature anthropomorphism at higher frequency of role play. Conversely, for children who impersonated, there was no significant linear or curvilinear relation ($p$s > 0.32) between role play frequency and technology-nature anthropomorphism.

For the animal subscale, the linear model produced a significant fit, $F(6,78)$ = 2.57, $p$ = 0.03, $R^2$ = 0.17, that was not significantly improved by the quadratic model (**Table 3**). After controlling for the significant effects of age, significant differences



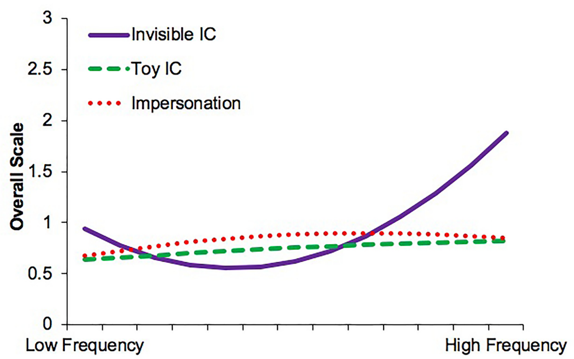




**FIGURE 2 |** Moderating effect of role play type on the curvilinear relation between anthropomorphism and frequency of role play.

were found in animal anthropomorphism between children with invisible ICs and those who impersonated (Model 1: Moderator 2, $p = 0.04$), but not compared with children with toy ICs (Model 1: Moderator 1, $p = 0.48$). Role play frequency was not a significant predictor, nor was the interaction of frequency with role play type. Notably, the significant effect of role play type on anthropomorphism of animals diverges from the non-significant ANCOVA results. As noted above, the non-significant ANCOVA results may have resulted from insufficient power. A *post hoc* power analysis on the linear regression using G*Power (Faul et al., 2007) with four predictors and an effect size of $f^2 = 0.3$ indicated observed power of 0.99, suggesting that the different statistical outcomes were due to power issues that were resolved in the regression.

Finally, on the overall scale, the curvilinear (quadratic) model produced the best fit, $F(6,78) = 3.03$, $p = 0.04$, $R^2 = 0.19$ (**Table 3**). There was a significant curvilinear relation between frequency of engagement and overall anthropomorphism (Model 2: Frequency$^2$, $p = 0.02$). Role play type moderated that relation when comparing children with invisible ICs to those with toy ICs (Model 2: Freq.$^2$ $\times$ Mod. 1, $p = 0.04$) and those who impersonated (Model 2: Freq.$^2$ $\times$ Mod. 2, $p = 0.004$). Evidence of the curvilinear relation between role play frequency and overall anthropomorphism as moderated by role play type is illustrated in **Figure 2**. As with the technology-nature subscale, we then tested whether a linear or curvilinear (quadratic) association was significant for each type of role play. Children with invisible ICs had a significant U-shaped curvilinear relation, $b = 0.11$ [0.01, 0.21], $t(2,15) = 2.26$, $p = 0.04$, evidenced by a slight negative association between frequency of role play and overall anthropomorphism at low frequency of role play that became stronger and positive as frequency of role play increased from moderate to high. However, on the overall scale, there were no significant relations (linear or curvilinear) for children with toy ICs ($ps > 0.65$) or those who impersonated ($ps > 0.21$). Given that the overall scale disproportionately weights the eight technology and inanimate nature items relative to the four animal items, it is not surprising that the overall scale more closely resembles the Technology-Nature subscale than the Animal subscale.

# DISCUSSION

## General Discussion

The present study provides initial evidence of a meaningful relation between children's role play and anthropomorphism. This work marks a preliminary step toward addressing the question of whether role play and anthropomorphism are related, and potentially rely on a common simulation process of imagining others' minds and internal states. Harris (1992, 2000) has argued that pretense (in the form of role play) involves a dual-process of simulating and projecting internal states, whether projecting others' imagined mental states onto oneself (impersonation) or projecting imagined personalities onto a stuffed animal or invisible friend (ICs). We propose that anthropomorphism similarly involves the process of simulation and projection of internal states onto non-human others (e.g., animals, inanimate nature, or technologies). As an initial step in addressing this question, we reasoned that if role play and anthropomorphism involve a similar underlying process of simulation and projection of internal states and minds, then there should be a correspondence between children's tendency to engage in role play and their tendency to anthropomorphize. Moreover, higher forms of role play should be related to attributing internal states to the least likely candidates (i.e., inanimate nature and technology), as both would involve greater imaginative processes.

The results from this study provide preliminary evidence consistent with our predictions. First, our findings indicate that the imaginative act of impersonation (i.e., pretending to be another entity) was positively related to anthropomorphism in general, and specifically the anthropomorphism of inanimate nature and technology. That is, children who impersonated more broadly across entities (animals, people, and/or machines) were more likely to anthropomorphize, especially inanimate nature and technologies. Whereas children who were more restrictive in who or what they impersonated tended to anthropomorphize less. Said differently, as this finding is correlational, children who more readily anthropomorphized were more likely to impersonate animals, people, and/or machines, and those who anthropomorphized less were less likely to impersonate.

Second, the results suggest that anthropomorphizing animals versus technology and inanimate nature may require differing *degrees* of imagination. Consider that animals provide numerous cues of agency and internal states (e.g., face, animate movement) – what has been termed 'target triggers' (Waytz et al., 2013) – and therefore may necessitate a lower level of imagination in order to attribute internal states. On the other hand, inanimate nature and technology lack such external cues of agency and internal states (i.e., target triggers), and therefore may require greater levels of imagination in order to attribute internal states. Given that, it is not surprising that children anthropomorphized animals more than technology and inanimate nature. Yet, over and above these differences, we found a pattern of results that suggest individual differences in role play may reflect differences in the degree to which children tap into the simulation process. That is, children who more readily imagine (or simulate) others' mental states do so both in the context of role play and anthropomorphism.

The evidence in support of this suggestion comes in two forms. First, let us consider the differences found in anthropomorphism by role play type. The regression analysis indicated differences in anthropomorphism of animals by role play type: Although children with invisible ICs did not differ significantly from those with toy ICs, children with invisible ICs anthropomorphized animals significantly more than those who impersonated (recall that the ANCOVA was underpowered to statistically detect these group differences although the pattern was consistent with the regression analysis).

We also found differences by role play type in the anthropomorphism of technology and inanimate nature. Here, children with invisible ICs were more likely than those with toy ICs to anthropomorphize technology and inanimate nature. Arguably, children with invisible ICs are more advanced in their imaginative abilities, as an invisible IC lies completely within the realm of imagination. On the other hand, children with toy ICs may be constrained in their imaginative possibilities by the physical features of the toy, and as a result tap into the simulation process to a lesser degree. In line with this reasoning, Tahiroglu et al. (2011) found that 5-year-olds with invisible ICs demonstrated advanced imagery abilities compared to those with toy ICs. Moreover, children with invisible ICs have better theory of mind (Taylor and Carlson, 1997) and mental representation abilities (Taylor et al., 1993). Yet, we also found that children who exclusively impersonated (and did not have a toy or invisible IC) anthropomorphized technology and inanimate nature to nearly the same degree as children with invisible ICs. This finding appears counter to our expectation that more sophisticated forms of role play should be associated with greater tendencies to anthropomorphize. However, further consideration suggests this piece of evidence may be consistent with our premise. That is, children who exclusively engaged in impersonation are not bound in the personas they simulate. In any moment, they might pretend to be an astronaut, a rhinoceros, or a Martian. As a result, impersonators may be readily tapping into the simulation process as they impersonate a broad array of characters.

The second piece of evidence comes from our finding that children who most *frequently* engaged with their invisible ICs had the highest rates of anthropomorphizing technology and inanimate nature compared to all other role play groups. This finding suggests that the repetitive engagement in simulating and projecting mental states in one context may lead children to more readily engage in the simulation process in other contexts (role play to anthropomorphism, or vice versa). Intriguingly, the frequency of role play alone was not explanatory, rather the association between frequency and anthropomorphism (overall and technology-nature) depended upon the form of role play. Recall from the regression analysis that children with invisible ICs anthropomorphized technology and inanimate nature more as their frequency in engagement in this form of role play increased from moderate to high. However, children with toy ICs had only modest increases in anthropomorphism when their engagement in role play increased in frequency. Why might this be the case? Consider again our argument above that the form of role play may differentially draw upon the child's imaginative abilities. Children with invisible ICs are completely unbound in the characters they create, and as a result may engage most substantively in the simulation process. As a result of greater imaginative abilities, in the absence of target triggers, these children may be better equipped or more inclined to 'fill in the blanks' with inanimate nature and technology. Thus, the level of imaginative ability associated with these more advanced forms of role play are associated with higher levels of mental state attribution to technology and inanimate nature. On the other hand, the imaginative potential for children with toy ICs might be limited by the physical features of the toy such that it is difficult for children to overcome the particular physical characteristics of a toy when imbuing it with a persona. As a result, they may engage less deeply in the simulation process – a limitation that is not wholly overcome by engaging more frequently in this form of role play.

Although children who impersonate have arguably fewer bounds in that they can impersonate any number of personas or characters, they nonetheless tend to impose limits by frequently impersonating familiar roles (e.g., mom) or storybook characters (e.g., Superman) (Carlson and Taylor, 2005), rather than generating a completely novel entity. This study did not assess the characters or persona children impersonated, thus we cannot know whether children who only engaged in impersonation tended to impersonate novel personas or known characters. However, our results do point to an interesting lack of relation between frequency of impersonation and anthropomorphism: Regardless of the frequency of impersonation, children who impersonated did not differ in their anthropomorphism (overall and technology-nature). The absence of this association stands in contrast to the significant curvilinear relation found for children with ICs – both showed increases in anthropomorphism of technology-nature and overall as the frequency of role play shifted from moderate to high. As with Carlson and Taylor (2005), it is possible that impersonators in the current study were often enacting known characters or roles rather than generating novel personas. In so doing, these children might be behaviorally enacting these characters, rather than deeply tapping into the simulation process of imagining these character's internal states.

Why might it be the case that higher levels of imagination are associated with more anthropomorphism? We argue above that by more deeply engaging in the simulation process, children may be more inclined or equipped to simulate and project mental states in other contexts. Here, we lay out an additional, complimentary explanation that helps unpack why children may anthropomorphize the least likely candidates for mental state attribution: inanimate nature and technology. Carlson (2010) has argued that higher levels of imagination involve a freeing up of top-down conscious control in order to allow for greater imaginative products. Accordingly, it may be that children with greater imaginations (vis-à-vis having a frequent invisible IC) may use less conscious control, in general, when imagining others' minds and internal states and are able to more readily attribute internal states to the least obvious candidates – inanimate nature and technology. In other words, these children are not constrained by the lack of target triggers or external cues of mental states when they simulate and project mental states, whether onto an invisible friend or technology and inanimate nature.

Finally, in light of the positive relation between role play and anthropomorphism, one lingering question regards children's level of commitment to their anthropomorphic beliefs. To explore this question, we must first unpack a critical difference between role play and anthropomorphism. In the case of role play, children are quite clear on the distinction between pretense and reality (Woolley and Wellman, 1993; Taylor, 1999; Gleason, 2013; Woolley and Ghossainy, 2013). That is, although children may be immersed within the imaginary space, they maintain a clear grasp on what is real and what is pretend. Accordingly, in terms of level of commitment, children have low commitments to their pretend attributions (i.e., they know they are just pretend). Conversely, individuals may express varying levels of commitment to their attributions when anthropomorphizing, in line with Epley et al.'s (2008) weak and strong forms of anthropomorphism. Weak anthropomorphism reflects a low-level of commitment, wherein individuals engage in 'in-the-moment' mindless (non-deliberate) behaviors that are not substantiated by their explicit judgments (e.g., Nass et al., 1993; Nass and Moon, 2000; Kim and Sundar, 2012). For example, one may act as if their computer has intentions (e.g., "You always try to update right when I need to give a presentation!"), and at the same time not explicitly believe their computer has intentions. Thus, like pretense, weak anthropomorphism involves a divergence between a person's explicit claims and their in-the-moment behaviors. However, the difference between pretense and weak anthropomorphism lies in the individual's level of awareness: One is aware of their pretense, but more often likely to be mindless when engaging in weak anthropomorphism (Nass and Moon, 2000). Strong anthropomorphism, on the other hand, is marked by explicit commitment to anthropomorphic beliefs, and a consistency between one's behaviors and their expressed beliefs (e.g., believing their dog has emotions and treating them accordingly).

What form of anthropomorphism – weak or strong – do children's attributions reflect? Given that our study measured anthropomorphism with an explicit measure (IDAQ-CF), we argue that our results reflect the strong form of anthropomorphism. That is, we argue that explicit anthropomorphic attributions are more likely to reflect a higher level of commitment. At the same time, children were judicious in the degree to which they attributed anthropomorphic characteristics to non-humans. Recall that children's attributions were nowhere near ceiling levels, but rather were at the lower-end (for inanimate nature and technology) and mid-point (for animals) of the 3-point scale. Thus, children may be committed to their attributions, even when they are conservative in the degree to which they endorse anthropomorphic attributes (e.g., being sure that an insect thinks for itself only a little).

## Limitations

The current study has several limitations that warrant consideration. First, this study involved a single-time-point correlational design to investigate the relation between role play and anthropomorphism. Although the results are consistent with our proposal that role play and anthropomorphism involve a common process of simulation and projection, any firm conclusion to that effect would be premature and go beyond the existing data or study design. Certainly, questions about causal relationships between role play and anthropomorphism would require time-lagged, longitudinal, or experimental designs. Second, our anthropomorphism measure relied exclusively upon self-report. Although we found variability in children's use of the IDAQ-CF scale (thus rendering unlikely a yes bias in their responses), other factors may have affected how children responded on this measure. Our role play scale similarly relied upon children's self-report, however, in this case their reports were largely corroborated by their parent. That said, additional behavioral measures of role play, such as free play with real- and fantasy-oriented toys, pretend actions (Taylor and Carlson, 1997), or the toy phone task (Taylor et al., 1993; Tahiroglu et al., 2011), would provide a more comprehensive and robust measure of engagement in role play. Third, the two measures were presented in the same order (IDAQ-CF followed by the Role Play Measure), thus we were unable to assess or control for potential order effects. Finally, this work should be replicated to guard against the possibility of a spurious finding and would be strengthened by including a larger (i.e., to increase power) and more representative sample.

## Future Directions

Research on the development of anthropomorphism is in its nascent stage, and much work remains in order to understand the causes, correlates, and consequences of the tendency to ascribe human-like mental states to animals, artifacts, and nature. Indeed, the current study is a starting point for understanding the relation between role play and anthropomorphism. Future work here should focus on investigating the specific mechanisms that may underlie a general process of mind attribution. For example, do more general cognitive abilities explain the relation between role play and anthropomorphism? Accordingly, future research would benefit from the addition of measures of cognitive abilities (e.g., executive function, theory of mind, analogical reasoning), as well as other control measures associated with mentalizing abilities (e.g., birth order, multilingualism). It will also be important to test whether anthropomorphism can be causally linked to role play, for example by experimentally testing whether increases in role play would result in increases in anthropomorphism. Importantly, future work examining frequency of engagement in role play needs to be considered in light of the form of role play, as the curvilinear relation between frequency of engagement and anthropomorphism of technology and nature and in general is moderated by role play type. Future research could also assess whether the nature of the relation between role play type and anthropomorphism undergoes a qualitative shift across age groups. In addition, the current study has raised questions regarding children's level of commitment to their anthropomorphic attributions. We have argued above that children's explicit judgments on the IDAQ-CF reflect a strong form of anthropomorphism (i.e., high commitment), however, this interpretation is conceptual rather than empirical. Thus, future research could directly assess how committed children are to their attributions, and whether their level of commitment undergoes developmental change. That is, a strong commitment to anthropomorphic beliefs may reflect a less advanced understanding. Whereas, a lower level of commitment to one's anthropomorphic attributions may reflect a more sophisticated and nuanced appreciation that ascertaining whether non-human others have mental states is a challenging, if not futile, task (e.g., Nagel, 1974).

In addition, we suggest three distinct lines of research that are particularly relevant to understanding the development of anthropomorphism, as well as the variation between individuals (whether innate or a result of experience) and cultures.

We have argued that, like role play, anthropomorphism involves a process for ascribing mental states onto others, whether a toy or stuffed animal (in the case of role play) or a non-human entity (in the case of anthropomorphism). Relatedly, Harris (2000) has argued that simulation underlies both role play and theory of mind. Previous research has shown links between pretense (and role play, specifically) and theory of mind (e.g., Astington and Jenkins, 1995; Taylor and Carlson, 1997). Although, as pointed out by Dore et al. (2015), there is conflicting evidence regarding any directionality between pretense and theory of mind. One interpretation of the conflicting directional evidence is a third variable: Both may involve a common underlying process. The current paper makes a third link—that is, the speculation that simulation also underlies anthropomorphism. In other words, it is possible that the process of simulation and projection of internal states to others includes other people (theory of mind), imagined others (role play), and non-human others (anthropomorphism).

Thus, one line of future research might explore the relation between anthropomorphism and theory of mind (see also Atherton and Cross, 2018). As previously discussed, there is evidence that anthropomorphism activates the same neural network as theory of mind (Castelli et al., 2000, 2002). Interestingly, Castelli et al. (2002) found that, in response to viewing anthropomorphized animated shapes, individuals with high-functioning autism provided fewer and less accurate interpretations of putative mental states and showed less activation of the mentalizing network. At the same time, individuals with autism demonstrated similar activation as typical adults of an additional region – the extra-striate visual cortex. However, unlike typical adults, those with autism had poor connectivity between the extra-striate cortex region and the mentalizing network. The authors suggest the results point to a physiological explanation for theory of mind deficits among individuals with autism; that is, information from lower-level perceptual (visual processing) areas is not transmitted to the higher-level mentalizing network. These results provide neural evidence of a link between theory of mind and anthropomorphism in typical adult, as well as a neural explanation for the difficulty individuals with autism have interpreting animate shapes in mental terms.

Yet, there may be a critical difference between *perceiving* animated objects in mentalistic terms and explicitly *ascribing* them mental states. A recent study found that roughly half of adults with autism spontaneously personify objects (White and Remington, 2018). This finding may call into question the logic of our argument that social cognition and anthropomorphism are related. White and Remington suggest this result is particularly striking given that roughly half of autistic individuals experience difficulties identifying their own emotion (alexithymia). However, as participants' emotion understanding – their own or others' emotions – were not assessed (nor other aspects of theory of mind), it is not possible to know whether the 56% of participants with autism who reported personifying objects also experienced alexithymia. Nevertheless, these results underscore the importance of additional research on any links between attributing mental states to humans (theory of mind) and non-humans (anthropomorphism). It may be, as White and Remington suggest, that anthropomorphism "may result from difficulties mentalizing" (p. 3). To this point, we propose two related avenues of inquiry. First, it will be important to explore potential links between anthropomorphism and *accuracy* in theory of mind understanding (e.g., emotion understanding, perspective taking, knowledge attribution, etc.). This line of investigation would shed light on whether the tendency to anthropomorphize is associated with a *lack* of accuracy in understanding other people's minds, or vice versa. Second, and relatedly, future research should also consider the relation between anthropomorphism and the *propensity* to make inferences about others' minds, what has been termed mind-reading motivation (Carpenter et al., 2016). Carpenter et al. (2016) have found that one's accuracy in interpreting others' mental states is distinct from (although weakly related to) their propensity or motivation to do so. Thus, independent of individual's accuracy in mind-reading, future work could investigate whether anthropomorphism is more likely to arise in individuals with a greater willingness to attribute mental states to others – what we may think of as 'promiscuous social cognition.'

Finally, a critical question regarding any potential link between theory of mind and anthropomorphism is whether the association would be the same for animals as it is for technology and inanimate nature. As evident in the current study and previous research (Waytz et al., 2010a; Severson and Lemm, 2016), these forms of anthropomorphism are distinct. As we argued above, animals may be more readily anthropomorphized as they provide numerous external cues of internal states. Accordingly, the simulation process applied to humans (theory of mind) may be more akin to that applied to animals as both provide external cues that may more readily allow for inferences of internal states. However, technology and inanimate nature provide few, if any, external cues and therefore may draw upon different aspects of theory of mind and/or other cognitive abilities (e.g., visual imagery). Thus, the distinction between anthropomorphism of animals and anthropomorphism of technology and inanimate nature should be maintained in future work.

A second line of future research might investigate whether anthropocentric biases may interact with children's tendency to anthropomorphize. Anthropocentrism refers to the tendency to use humans as a prototype for reasoning inductively about non-humans, wherein children asymmetrically extend unobservable novel biological properties from a human to a target animal, plant, or object, but not vice versa (Carey, 1985). Interestingly, rather than being a foundation for inferring knowledge about non-humans as initially theorized (Carey, 1985), subsequent research has shown that experience and social learning play an important role in children's anthropocentric biases (Waxman and Medin, 2007; Herrmann et al., 2010). Compared to urban children, children from rural environments and Native American communities do not exhibit an anthropocentric bias, presumably due to more direct experience with animals and nature (Bang et al., 2007; Medin et al., 2010). Moreover, children in urban environments show less of an anthropocentric bias when they have pets (Inagaki, 1990; Geerdts et al., 2015) or parents with biological expertise (Tarlowski, 2006). Although anthropocentrism and anthropomorphism are arguably distinct (e.g., anthropocentrism is evident among urban children for a relatively brief period, whereas anthropomorphism is found in children and adults; Geerdts, 2016), future research could explore whether anthropocentrism is related to anthropomorphism. On the surface, it stands to reason that they would be associated to the extent that they both involve the attribution of unobservable internal characteristics (whether biological or mental) from humans to non-humans. Indeed, there is evidence that anthropomorphic storybooks can influence children's tendency to reason anthropocentrically (Waxman et al., 2014). Alternatively, it may be that substantive differences exist between anthropocentrism and anthropomorphism, especially when considering differences in culture and experience, in addition to differing underlying cognitive processes involved in conceptual understanding versus social cognition.

Finally, a third promising line of research would explore cultural variation in anthropomorphism. As discussed above, it seems likely that culture would play a role in anthropomorphic beliefs as metaphysical beliefs and societal norms differ widely. Some have also argued that cultural differences in self-construal (i.e., perceptions of self as independent versus part of a collective) may procure differences in the tendency to perceive minds in non-humans (Waytz et al., 2013). In the adult literature, there is evidence of universality in agency detection in human faces (Looser and Wheatley, 2010) and inferences of intentions based on motion (Barrett et al., 2005), yet there is a surprising lack of cross-cultural research on mind attribution to non-humans. Anthropological study has provided initial evidence of cultural differences; that is, primatologists in Japan anthropomorphize to a greater extent than their United States counterparts (Asquith, 1986). In a more recent study with adults, Ghuman et al. (2015) found higher rates of anthropomorphism (as measured by the IDAQ; Waytz et al., 2010a) among adults in China and India compared to United States adults. Therefore, this line of research is ripe with opportunity to identify the patterns and causes of cultural variation in anthropomorphic beliefs.

## CONCLUSION

The present study provided initial evidence of a link between children's role play and anthropomorphism. We proposed that role play and anthropomorphism involve a common simulation process of mental state attribution, and our results were consistent with this proposal insofar that a positive relation was found between the tendency to engage in role play and the tendency to anthropomorphize. Moreover, our results provide evidence that differing degrees of imagination are involved in anthropomorphism of animals versus technology and inanimate nature. Future work is needed to corroborate the link found in the current study and, importantly, to identify whether there are specific underlying mechanisms. More generally, research on the cognitive underpinnings of anthropomorphism is in its beginning stages, and it represents an area rich with interesting and important questions.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

## AUTHOR CONTRIBUTIONS

Both authors made substantial intellectual contributions to this paper and approved it for publication. RS conceived the study, collected the data, analyzed the data, and wrote the manuscript. SW analyzed the data and wrote the manuscript.

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# Anthropomorphism in Human–Animal Interactions: A Pragmatist View

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This paper explores anthropomorphism in human–animal interactions from the theoretical perspectives of pragmatism and anthropology of human–animal communication. Its aim is to challenge the conception of anthropomorphism as the attribution/inference of human properties to a non-human animal – particularly as a special case of the theory of mind. The author's goal is to articulate a plausible an alternative conception of anthropomorphism as a situated direct perception of human properties by someone who is engaged in a given situation and sensitive to what the animal is doing to them. Rooted in pragmatist theory as well as in contemporary anthropological studies, this paper offers an original perspective for in depth ethnographic and empirical studies of anthropomorphism-in-situation. Such studies could bring new insights in the study of how ordinary people make sense of animal behaviors in real-life situations.

**Keywords: anthropomorphism, human–animal interaction, animism, pragmatism, relationality, expressive gesture, direct perception**

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## INTRODUCTION

How do people manage to make sense of animals? One answer, provided by the biologist and anthropologist Bateson (1974–1991), is that people make sense of plants or animals when they can perceive the "pattern which connect" them to that animal or plant. As a form of poetic introduction to the problem of anthropomorphism, I would like to cite an excerpt from a poem by William Wordsworth already used by Bateson in a paper about aesthetics entitled "The creature and its creation." In this poem Wordsworth mocks a man in these words:

> 'A primrose by a river's brim
> A yellow primrose was to him
> And it was nothing more'

Because the primrose is "just" a yellow thing over there, this man is unable to relate to the flower. In contrast with this man, stands the poet, to whom, according to Bateson, the primrose can be something more: a self-reflexive recognition. "The primrose resembles a poem and both poem and primrose resemble the poet." (Bateson, 1974–1991, p. 269). Something of the poet is perceived to be present "in" the primrose itself. In the introductory section of Mind and Nature (Bateson, 1979), Bateson also evokes this poem, arguing that this recognition allows the primrose to become *relevant* to the poet, because through this recognition, the poet discovers that he is part of the same story as the primrose. Thus, according to Bateson, to make sense of something is to be able to share a story with it, and this is how people make their environment – both human and non-human– *relevant*. "I would assume that any A is relevant to any B if both A and B are parts or components of the same 'story' (Bateson, 1979, p. 13) – and for Bateson, being a part of biological evolution is sharing a story.

At first sight, the aesthetic experience of the poet has nothing in common with anthropomorphism, if anthropomorphism is defined as the conscious "attribution" or "inference" of human characteristics to a non-human being. The poet's experience seems to be completely different: it has to do with the *direct perception* of some human – yet indeterminate – qualities in the flower.

Still, the story of the primrose indicates the direction of the discussion that will follow. The main argument is that in everyday life, animal mental qualities are not so much inferred as they are recognized, or directly perceived, by a human being who is engaged in a specific interaction. This point of view is defended by Gallagher (2008) in the context of human social cognition and by Morris (2017) in the context of human-animal interaction. The approach advocated here is in line with the "embodiment approaches" that Morris (2017) identifies as promising alternatives to the theory-of-mind approaches of animal minding. Morris criticizes the theory-of-mind approaches because they all assume that "there must be some cognitive process or mechanism that is operating to allow people to bridge the gap between observable behavior and mind" (Morris, 2017, p. 2). On the contrary, says he, the essence of embodiment approaches is that "mind is embodied in behavior" or that "mind is directly available in behavior" (ibid., p. 3).

Accordingly, the aim of this paper is to provide a convincing theoretical framework to support such a claim. It draws mainly on the pragmatist perspective of J. Dewey and G. H. Mead, but also on anthropologists T. Ingold and K. Milton's current use of the affordance theory of J. Gibson and on G. Bateson's theory of communication. The framework is elaborated systematically, along with a discussion about empirical studies of anthropomorphism, contemporary anthropological analysis of animism, and ethnographic studies of human–animal interactions. It tries to identify the conditions in which animal mental qualities can be perceived directly and it leads to a definition of anthropomorphism as the *situated direct perception* of animal minds (or other human properties) in the behavior or bodily expression of animals, by someone who is engaged in a specific process of activity. In a pragmatist perspective, anthropomorphism is a social activity that cannot be studied separately from its context of appearance. Its description and analysis must be achieved through careful ethnographic studies of real-life situations.

The first section examines previous studies of anthropomorphism and concludes that the concept of anthropomorphism as an act of inference is valid only in the context of the *scientific* activity of minding animals. In the non-professional activity of anthropomorphizing animals, people are not acting as distant or neutral observers of the animal's behavior, but on the contrary, they are engaged in some kind of *dialog* with their environment. The *dialogic structure* of anthropomorphism (Airenti, 2012) will be discussed and analyzed in relation with G. Bateson's theory of communication in the next section, leading to the conclusion that it is from the *inside* of a relationship (i.e., when they are affectively engaged) that people *see* human properties in animal's behaviors or anatomical features. Thus, anthropomorphism does not only depend on characteristics that are present in the animal, but also on the kind of relationship and interaction between the person and the animal. In other words, the perceptual cues for the recognition of mental qualities are out there, in the animal, but they are discovered by someone who is *doing* something.

The fourth section will try to answer this question: if mental qualities of animals are directly perceived, can Gibson's affordance theory (Gibson, 1979) account for anthropomorphism? In their analysis of animism in human–animal interactions, anthropologists Ingold (2000, 2002) and Milton (2002) convincingly claim that personhood is directly perceived by animist people in their environment. They provide ethnographic examples that clarify the kind of relationship in which such a perception occurs and call it a *relational epistemology*. In a relational epistemology, people turn their attention on what the animals (or plants) are *doing* to themselves and it seems that this affords for the direct perception of personhood in the surroundings. But the affordance theory is not enough for understanding of anthropomorphism because it leaves the social nature of the act of minding animals unexamined. The fifth section of the paper turns to empirical studies of human–animal interactions in the specific settings of the bio-medical laboratory. It is then obvious that the perception of affordances is not only learned, neither is it only dependent on the activity of the organism, it is also guided by materially and symbolically organized situations. To account for this, I introduce the concept of "perceptual frame." A perceptual frame is both a definition of the situation in Goffman's (1974) terms, and the performance of normative ways of attending to the animals, looking at them and letting oneself being affected – or not– by them. Through their very activity, people are trying to keep these perceptual frames alive and stable. Still, animals are living and acting beings, so unexpected affordances can emerge, inviting laboratory people to unexpected (or unwanted) kinds of relationships. In this perspective, animal's (ontological and ethical) status is always provisional and unstable, and this is precisely what is found in the anthropological analysis of the (direct) perception of personhood in plants and animals, as well as in the ethnographic studies of human–animal interactions in laboratory facilities that are reported in the sixth section.

In contrast with the inference theory, the pragmatist perspective that I offer here is capable of considering the emergence of new significations in a situation. It shares the basic pragmatist view that perception is guided by the current activity: "What the sensation will be in particular at a given time, therefore, will depend entirely upon the way in which an activity is being used. It has no fixed quality of its own. The search for the stimulus is the search for exact conditions of action; that is, for the state of things which decides how a beginning coordination should be completed" (Dewey, 1896, p. 369). "Whatever we are doing determines the sort of a stimulus which will set free certain responses which are there ready for expression, and it is the attitude of action which determines for us what the stimulus will be" (Mead, 1936, p. 366). This perspective also assumes that people don't "passively" and intellectually perceive the animals but that they rather "find" some stimulus in the animal's behavior or anatomical structure that allow for the continued course of action. But the action is social, and in this, they are supported by culturally and socially learned modes of attention, ontological definitions of animals, and by materially and symbolically designed situations.

## IS ANTHROPOMORPHISM AN ACT OF INFERENCE?

Many authors subscribe to a definition of anthropomorphism akin to the one provided by Guthrie (1997): anthropomorphism is "the attribution of human characteristics to non-human things or events" (p. 51). Even if definitions may differ on "what" precisely is attributed to the "non-human things and events," there seems to be a consensus on the fact that anthropomorphism is a specific case of inference of something human to a non-human entity (Fisher, 1991; Eddy et al., 1993; Herzog and Galvin, 1997; Mitchell and Hamm, 1997; Silverman, 1997). In this perspective, anthropomorphism rests upon a cognitive work of inference.

This approach to anthropomorphism is indeed in line with the first theory of anthropomorphism, developed by Romanes and Morgan at the end of the 19th-century (Costall, 1993; Morris et al., 2000). Morgan proposed the word "ejective inference" while Romanes talked about "double inference," in order to describe the double process of inference that supposedly took place when the scientist attributed mental qualities to an animal. The inference goes first from the observation of the animal's behavior to one's experience, where it is compared with one's mental experience, and then it goes from one's experience to the mental qualities attributed to the animal. According to these 19th century authors, inference of this kind was the only way in which a scientist could safely attribute intentions or other mental states to another animal. Because mental traits are "hidden" behind the behavior, they must be recovered through a double act of inference.

Yet, it should be noted that this kind of inference is the achievement of scientists who were searching for a safe way of studying animal minds in a Darwinian perspective. It is by no means a description of what people do when they are interacting with animals in everyday life. This has been made very clear by Costall (2007), who distinguishes between:

(1) Anthropomorphism as relating to other animals as subjects and agents, with feelings intentions, needs, and so on. This is what happens in everyday life, and it does not necessarily entail that we are dealing with "hidden" mental traits that are inferred;
(2) The *method* of anthropomorphism, a method committed to a dualism of mind and behavior. "This method assumes that making sense of animals as subjects necessarily entails an intellectual process of inference or "attribution" to bridge the gap between what we can observe (behavior) and what is supposed to be hidden (the mind), and such inferences are to be based on analogy from one's own introspection" (Costall, 2007, p. 87).

Applying the model of anthropomorphism-as-inference as a general model of how people make sense of animals would mean considering the communicative and interactional structures that prevail in the behaviouristic operationalism of the laboratory as also operating in the life world. However, this is probably not the case. Indeed, the life-world is excluded by the practical methodology of the laboratory (Wieder, 1980; Rollin, 1990).

Researchers themselves have long noticed that, while they painstakingly try to use logical criteria to identify mental attributes in animals, their practical-minded assistants intuitively "find" mental phenomena that work for them (i.e., Silverman, 1997). Animal keepers rely on a very different (and much more efficient) way of understanding animals, which makes them able to *see* chimpanzees as conscious being or "embodied consciousness" (Wieder, 1980).

So, in spite of the fact that several authors insist that the researcher and the animal keeper (or the non-professional) are doing different things when they are minding animals, surprisingly, when it comes to empirically study anthropomorphism, the scientific stance (anthropomorphism-as-inference) is taken for granted and chosen as the model. Anthropomorphism is thus considered as a detached, decontextualized and intellectual operation, "one of many examples of induction whereby people reason about an unknown stimulus based on a better-known representation of a related stimulus, in this case reasoning about a non-human agent based on representations of the self or humans" (Epley et al., 2008, p. 145). Anthropomorphism is seen as a special case of the theory of mind, where "interpersonal understanding is seen as a theoretical accomplishment, involving a person constructing and using a "theory" of other people's minds, as well as their own. Applying the theory to observable behavior enables the individual to interpret that behavior in intentional terms and as the product of specific mental states" (Leudar et al., 2004, p. 572).

It would nevertheless be obvious to a pragmatist that the activity of the detached and neutral observer (the scientist) and the activity of the non-professional who is affectively engaged in an interaction are two very different kinds of situations, which afford different ways of knowing. Disregarding this simple fact lead to the erroneous assumptions that similarity is a crucial determinant in anthropomorphism.

## ANTHROPOMORPHISM AND HUMAN–ANIMAL SIMILARITY

As long as it is defined as the (decontextualized) attribution of human qualities to animals, anthropomorphism can be empirically studied through questionnaires asking people to attribute more or less complex cognitive and emotional states to animals. The first empirical studies of anthropomorphism (Eddy et al., 1993; Gallup et al., 1997; Herzog and Galvin, 1997) used this method and asked subjects to rate different animal species according to their supposed cognitive and emotional abilities. The results were rather convergent. They showed that the more the animals were considered similar or close to human beings, the more they were endowed with mental complexity. These results allowed Gallup et al. (1997, p. 91, my emphasis) to conclude that "the *use of anthropomorphism* appears to be influenced by the perceived similarity between humans and animals and the extent to which people have developed an affectionate bond with members of the species in questions (e.g., dogs and cats)." Additionally, the authors take these results as an evidence that anthropomorphism is, indeed, the result of an inferential work: "We contend that anthropomorphism is a by-product of self-awareness and the corresponding ability to infer the experience of other humans by using one's own experience as a model" (p. 91). In opposition to this, I would state that what has actually been studied there is a cultural conception of animals that is only distantly related to anthropomorphism as it works in real-life situations. Actually, the results show what people commonly *think* about human–animal proximity and animal mental states – and, as Airenti (2012) reminds us, there is a big difference between believing that the coffee machine has intentions and behaving as if it had. Given the general education level of psychology students (who are often taken as subjects) the fact that they rate mammals as closer to human beings than invertebrate, and that they attribute more complex cognitive abilities to dolphins and apes than to pigs or rats is not surprising. Yet, knowing how people classify animals according to what they believe about their mental properties doesn't say anything about what they do when they are actually interacting with them or even observing animals' actual behaviors.

A study by Mitchell and Hamm (1997) specifies the role of perceived similarity in anthropomorphism. They gave undergraduates narratives depicting mammals' behaviors (including human beings) suggestive of jealousy or deception. They then asked the subjects to evaluate their degree of agreement or disagreement with psychological characterizations of the animals described. The narratives presented various contexts and species (more or less close or familiar to human beings), but the behaviors remained constant. In these conditions, only variations *in the context* influenced the psychological characterizations. The species did not. The authors concluded that the main criteria for the psychological characterization of animals is the perceived structure of the "behavior-in-context." This is not only more in accordance with the observations of Wieder (1980); Morris et al. (2000), and Servais (2012), it is also in agreement with the well-known fact that one can virtually attribute human properties to any object (Airenti, 2012). In Airenti's examples, a piece of wood can become a "baby" in children's play, and a coffee machine can be threatened by an angry user. Given this, we may doubt that similarity, or even plausibility, are the fundamental criteria for anthropomorphism. It might be the case when answering a questionnaire, but outside this very specific situation, something else is at play.

To make sense of seemingly contradictory experimental results of this kind, as regards anthropomorphism in children, Airenti (2012) suggested that anthropomorphism has two founding properties. Firstly, anthropomorphism is the expression of a basic teleological thinking, a way of *representing* non-human beings through their assimilation with human beings. Secondly, and most importantly, anthropomorphism manifests itself mainly in *interactions*. According to Airenti, for anthropomorphism to happen, it is necessary that the human characteristics be perceived in a specific interactional setting that she identifies as a *dialogic* relationship. She then suggests anthropomorphism should be seen as placing an object or an animal in the position of interlocutor in a dialogic relationship[1] (Airenti, 2012, p. 49, my translation).

## THE DIALOGIC STRUCTURE OF ANTHROPOMORPHISM

The implications of the dialogic structure of anthropomorphism for the perception of animal behavior may be examined along with G. Bateson's theory of communication. In a paper about mammalian communication (Bateson, 1963), he suggests that every message (intentional or not) should be considered a two-sided entity: it is both a *report* and a *command*. It is a report about a past event (i.e., an emotion) and a command or a stimulus for a reaction of the partner (i.e., a threat). Or, in Bateson's own terms: "The wag of the dog's tail which for individual psychology signifies an inner state of the dog becomes something more than this when we ask about the functions of this signal in the relationship between the dog and his master. [. . .. . .] It becomes an affirmation or a proposal about what shall be the contingencies in that relationship" (Bateson, 1963, p. 230). Simply speaking, the report is about the content of the message, while the command is about what the message does to the receiver, how it affects them and how it shapes the relationship. Every message has both aspects. Only the emphasis changes.

We can now see that the detached spectator (the scientist) is someone who makes oneself blind to the "command" aspect of a message. It means that they are not *affected* by the animal's communicative signals. The signal is just a "report," a bit of information about something else. Indeed, the best way to achieve neutrality when dealing with a living being, is precisely to make oneself impervious to the "command" aspect of the organism's behavior or communicative signals. It is the safest way not to feel the urge to act when seeing, for example, a "depressed chimpanzee" (lowered body, slower pace, loss of appetite, increased response time. . .). The main point here is that precisely because the detached spectators keep themselves from being affected, *they won't even see* a "depressed" chimpanzee; but only some behavior to be scientifically interpreted (i.e., neurophysiological cause). This deduction is in accordance with the phenomenological point of view that the perception of the behavior of certain things and beings is immediately given to us. Still this is only true for the *involved* consciousness, for "if we choose the 'being-in-the-world' of the detached spectator"

[1] Freely translated by the author from Airenti (2012, p. 49): "Toute familiarité est donc liée à la possibilité de placer un objet inanimé dans la position d'interlocuteur dans un dialog."

this given understanding disappears (Buytendijk, 1952, p. 19, my translation).

For example, in one biology laboratory studied by Arluke (1988), rats about to be guillotined were kept in a separate room so that they could not see or smell the beheadings. This was justified on the grounds that "significant emotive changes in the rats produced by high-frequency distress calls would compromise the data." (Arluke, 1988, p. 103). This is a good example of distress calls that are recognized as distress calls but do not call forth empathic responses as a distress call in a human infant might.

In the interactional setting of the disinterested or disengaged observer, inference is the only way to know about the animals' mind. On the contrary, in a dialogic structure, because I agree to be sensitive and be affected by it, the animal's experience becomes manifest through its expressive actions and body movements. Phenomenologists would say that knowledge of the animal's mind is given through the contextualized apperception of its expressive body. "A crucial part of learning to be a "chimper" [namely a talented animal keeper] is learning to read chimpanzees body movements and gestures, that is, to see them as appresenting – to see, for example, arousal and anxiety in the slight erection of hair on the shoulders and in a particular bobbing motion *in some particular context*" (Wieder, 1980, p. 94, underlined by the author). Accordingly, in their paper arguing for animals as psychological beings, Bateson (1979) claim that expression is the heuristic route to direct knowledge of the mental states of others and that expression *is only visible from within* relationships (Bateson, 1979, p. 175).

Phenomenologically, a dialogic relationship can be conceptualized as a double move (Buytendijk, 1952). There is a move toward others in order to seize them (and this is the first property of anthropomorphism identified by Airenti) – and there is a move of offering, giving ourselves up in such a way that something might happen to us. Such a move can only be found when one agrees to be receptive to the "command" aspect of animal's behavior, signals, or even anatomical shape or color. In the case of the piece of wood that becomes a baby, cited above, the child is responsible for the piece of wood's moves, but nonetheless sees them as expressive movements, and responds accordingly. Inside this creative "as if" relationship, and only from the inside of this relationship, is the child able to *see* the piece of wood as a baby. For anyone else, it is just a piece of wood[2].

We are now in a position to conclude that mental qualities are directly perceived from the inside of a relationship. How can this be, if nothing is inferred? For phenomenologists like Buytendijk or Wieder, mental states are directly appresented by expressive bodies: we do not meet bodies, but embodied consciousness. Could a pragmatist framework shed some light on the very question of the direct perception of mental – or human – properties? If we use Gibson's affordances theory, I think it could. This isn't aberrant. Both approaches have much in common, even if they differ on some points (Noble, 1981). Moreover, this theory has precisely been used by anthropologists who sought to analyze animism – which is the perception of human qualities in the natural environment.

## AFFORDANCES AND THE DIRECT PERCEPTION OF THE ENVIRONMENT

Gibson's theory of affordances (Gibson, 1979) is the theory of a direct perception of the environment by a subject who is involved in his environment. It has been used by anthropologists Ingold (2000, 2002) and Milton (2002) to conceptualize the relationship between people and their natural environment, including animals. Affordances are "properties of the real environment as directly perceived by an agent *in a context of practical action*" (Ingold, 2002, p. 46, my emphasis). Affordance theory postulates that information is present in the environment, it doesn't need to be constructed by a subject. Meaning is not imposed, nor "attributed" by a disengaged observer upon environment, but it is *discovered* by someone who is implicated in, and oriented by a practical action. "The man throwing the stone did not, we suppose, first "construct" the stone as a missile by attaching a meaning or "throw-quality" to impressions of it received through the senses. [...]. Rather, it was the very involvement of the man in his environment, in the practical context of throwing, that led him to attend to the "throwability" of the object, by virtue of which it was perceived as a missile. Such direct perception of the environment is a mode of engagement with the world, not a mode of construction of it" (Ingold, 2002, p. 44).[3] In its insistence on the discovering of properties in the environment according to the involvement of the subject in a practical action, Gibson's perspective sounds very much like pragmatism. Perception is guided by the practical action, and the environment exist *for* a given organism. Indeed, organism and environment make "an inseparable pair" (Gibson, 1979, p. 18).

When she tries to understand the complex relationships that English conservationists have developed with the nature they strive to protect, anthropologist Kay Milton also draws on Gibson's theory of direct perception. This is particularly so when she addresses the question of the "personification" of nature (Milton, 2002, pp. 42sq). Consistently with Ingold, she makes it clear that environmentalists don't make nature and natural things *into* persons, they don't *construct* them as persons. Rather, they *see* them as persons: they "discover the personhood of nature and natural things by perceiving their person-like affordances" (Milton, 2002, p. 45).

It is important to note that the perception of "person-like" affordances in animals or natural things does not happen in *any* kind of relationship or interactive situation. Many people live among animals and don't see them as persons. In her search for the interactive conditions of the personification of animals, Milton turns to the work of Bird-David, an anthropologist who

[2]This example should not be taken as a claim that minding animals from the inside of a relationship equates to hallucinating non-existent movements. Still, it reminds us that anthropomorphism is more or less has linked with affect and imagination.

[3]Note that Tim Ingold has turned to affordance theory to object to the traditional anthropological conception of animals as "cultural construct" – a very old anthropological view that assumes that the entire signification is in head of the human being and that nature, animals, plants, etc. are pure materiality.

studied the Nayaka hunter-gatherers of South India. These people have a specific way of relating themselves to their environment that Bird-David called a “responsive relatedness” (Bird-David, 1999). Responsive relatedness is a way of engaging one’s attention to the surroundings. The Nayaka are attentive to the changes of things in the world *in relation to themselves*. In other words, their attention is turned to what things in their environment *do* to themselves rather than what they are. “Animals and other objects which actively engage their attention, stones which ‘come toward’ or ‘jump on’ them, elephants which ‘walk harmlessly’ or ‘look straight into the eyes’ are perceived as having a kind of personhood” (Milton, 2002, p. 46).[4] Milton adds that the sort of environmental knowledge the Nayaka express, and which Bird-David called a “relational epistemology,” has been identified many times by anthropologists, particularly in hunter-gatherer cultures. Many North American hunters describe not only animals, but a wide range of other natural phenomena as “persons” including trees, rocks, winds, the sky, and so on. This has generally been understood as evidence that hunter gatherers “believe” that animals, plants, wind, etc. have psychological properties and intentions. Nevertheless, Milton notes that such an interpretation is a gross falsification that led to a deep misunderstanding of animism. It is due to our modernist point of view, which sees animism as the attribution of personhood *to* natural things (through inference) rather than the perception of personhood *in* these things. In relational epistemology, personhood is not a property of something, it emerges out of what something does in relation to others. Ingold (2000) shares Milton’s analysis. For him, when Cree hunters describe their reindeer prey as *offering* its life to the hunter, they are not making a statement of fact about the reindeers. Rather, their description should be understood as “a performance of which aim is to give form of human feelings” (Ingold, 2000, p. 25) where feeling is “a mode of active, perceptual engagement, a way of being literally ‘in touch’ with the world” (ibid, p. 23). In other words, the Cree’s description is mistaken by the modernist observer as being about the “report” aspect of communication, although it should be understood as an account of the “command.” In the perspective opened by Ingold, the Cree’s description of the hunt will not be misunderstood as a “weird” or irrational conception of animals anymore. On the contrary, it is a very accurate and precise description of the experience of the hunter of being touched and moved by his prey.

The cultural interpretation varies, of course, but relational epistemology is probably not restricted to hunter-gatherer societies (Bird-David, 1999; Milton, 2002). I would argue that in both societies, our sensitivity to the personhood of non-human animals depends on the intensity with which they engage our attention and respond to what we do.

This discussion shows that the perception of personhood *in* the environment happens when people are sensitive to animals *in relation* to themselves. More precisely, they are sensitive to their own response to the animal’s behavior or anatomical features. In this situation, one doesn’t “construct” nor infer mental properties, but feels or sees them. In Bateson’s language of relations, we would say that the animal’s body or behavior affords a certain kind of relationship and that the mental qualities that are perceived “in” the animal emerge from this felt relationship. In this relational perspective, there is an interesting rapprochement to be noted with G. H. Mead’s reflexion about how objects acquire their “interior.” According to Mead, an object “gets its inside when it arouses in the organism its own response and thus the answering response of the organism to this resistance” (Mead, 1959, p. 136?).[5]

The theory of affordances allows us to understand how it is that a perceptual salience born by an animal (i.e., anatomical structure, a behavior, a gesture, or any specific shape) will be discovered or not by a human being, according to the practical action in which they are engaged. Now, the problem of anthropomorphism may be phrased as follows: how does it come to be that certain “traits” or “structures” on the animal (or plant) are “selected” and “aggregated” instead of some (or no) others? The affordance theory suggests that the kind of practical action in which one is engaged is determinant in the perception of affordances. However, the theory alone doesn’t help when it comes to the description and analysis of these practical actions and how they frame and constrain perception. Moreover, as Noble (1981) has perceptively noted, the theory itself is unable to account for the *social meaning* with which some objects are endowed. Noble claims that Mead’s theory of the social object is able to solve some of the problems encountered by Gibson when it comes to social meaning. As the next section will clearly show, animals are attended to in social settings. There is a *framing work* that organizes the perception and the attention of the people engaged in corresponding actions. As I conceptualize it, this framing work is realized both symbolically (through language and many other symbolic acts) as well as materially (through material devices such as chains, cages, etc.). As I see it, such perceptual frames are enacted permanently by people through their coordinated actions and perceptions in a situation. Still, because animals are living beings that do unexpected things, these perceptual frames are challenged and fragile I have chosen “perceptual frame” over Meads theory of the social act because the latter cannot account for the instability of emergent significations in the situation, nor can it help to single out specific frames as objects for investigation.

## KEEPING THE PIG IN THE RIGHT PERCEPTUAL FRAME

In his late work “Frame Analysis” (Goffman, 1974), the sociologist E. Goffman used the concept of *frame* to refer to the (mostly implicit) social definition of a situation. Each situation needs to be defined or framed as a specific occurrence of something, for example, “interacting with a pet dog.” According to the situational definition, some perceptual (behavioral, anatomical, etc.) cues will be perceived as affordances for the

[4]We could extend the example that Ingold has given about the stone and the perception of its “throw-quality” affordance by saying that in the kind of attention that is characteristic of responsive relatedness, I can even hear the stone saying “take me.”

[5]Examining this convergence more thoroughly in the scope of further research would be of interest.

current action. In a pragmatist view, there is a mutual definition of the perceptual frame and the practical action. As the perceptual frame helps guiding the action and discovering the affordances for the action, the current action confirms and stabilizes the perceptual frame so that the practical action can continue.

Coming back to laboratory life, it is clear now that between the scientists who make themselves blind to the "command" aspect of communication, and do not attribute mental qualities to animals, and the animal caretakers who engage in a subject-to-subject relationship with the same animal, and perceive it as minded, the difference is not just in the act of inference. It is not that they perceive the same animal but differ in their willingness to infer mental qualities. Rather, I argue that they *perceive* (or *enact*) different animals because they are engaged in different actions with them, within different interaction regimes. The extensive ethnographic work of Arluke (1988) in biomedical laboratories and their animal facilities offers many examples that provide a better understanding how technical, symbolic and practical devices contribute to construct and stabilize perceptual frames in the life world of their face-to-face interactions with animals.

Arluke's (1988) main finding is that laboratory animals don't have a single status but, on the contrary, are seen as objects *and* pets. He documents the transformation of "naturalistic" animals[6] into either objects or pets as a "social construction" of the laboratory animals. Here my focus will stay on the practical interactive conditions in which each status is actualized and how it affects anthropomorphism. From the point of view of pragmatism, what is constructed is less the animal itself than the perceptual frame in which the animal is directly perceived *as* object or pet. The "construction" work happens upstream from the face-to-face human–animal interaction. For example, animals are objectified through a set of procedures that involve technical, material and symbolic devices (cages, codes, etc.) that deprive them of their individuality and expressive capacities. These procedures and devices define the current activity and ascribe it to a recognizable category of activities. But their function is also to prepare laboratory workers to *perceive* animals *as* – mainly objects. They organize the activity toward the animals and orient perception. They help laboratory caretakers, technicians and scientists avoid being sensitive to the "stimulus" aspect of the animal's behavior. When these procedures fail, laboratory workers resort to specific strategies that help them keep the animal in the right perceptual frame. Arluke precisely describes the de-anthropomorphizing strategies used to objectify animals. Interestingly, they mainly have to do with perception and can be seen, in a broad sense, as "education of attention" (Ingold, 2001) devices.

(1) Animals are de-individualized, treated as a collective entity and labeled with a code that refers to the experiment in which they are enrolled. De-individualization not only facilitates the redefinition of the animal's nature. It also materially prevents laboratory workers from *seeing* them as individuals. In a laboratory, one post-doctoral student was asked to stop naming the sheep because it made it harder for the others to conduct their experiments. I would say that naming changes the perceptual frame: when they have a name, animals have the power of making themselves present in the eye of the human being. Their behavior and expressive movements now afford for a subject-to-subject relationship and this challenges their objectification.

(2) Animal bodies are deprived of expressive capacities. There is a strict separation between the experimental and the care-taking spaces and people try to avoid having conscious animals in the laboratory. When it couldn't be avoided, dog cages were kept facing the wall, and a surgical sheet was draped over the cages. Scientists usually don't see the animals while they are conscious. Yet, when it happens accidentally, the situation may be completely reframed, as it is the case in this example: "one day, [the P.I.] came into the laboratory when a dog was still awake, tied by a rope leash to the surgical table. He looked at the dog, mumbled, 'oh, god, what will my wife say now!' turned around, and left" (Arluke, 1988, p. 104). In another example, three technicians and two post-doc fellows had to wait for the P.I. while three conscious dogs were waiting for anesthesia in the laboratory. Absolutely no attention was given to the dogs, even when someone had to pass the dogs, and even when the dogs then approached the human, wagged their tails and tried to make eye contact. "There was no acknowledgment that the dogs were present" (Arluke, 1988, p. 105).

(3) Situational definition. According to Arluke, "nothing in the animal itself solely determines this definition" (Arluke, 1988, p. 104). Indeed, in one laboratory, one of the guinea pigs was selected randomly by the technicians as the laboratory mascot and pet. It was given a human name and was particularly admired for its intelligence. It was taught tricks and technicians found its behavior to be endearing. When it broke its leg in a cage accident, it underwent surgery to fix it. Next door, a dog similarly broke its leg but was consequently killed. This example shows clearly that it isn't some inherent properties of the animals that will trigger anthropomorphism or mental states attributions, but rather the perceptual frame that allows for the perception of some behaviors or properties as affording engagement and social interaction. Affordances may be present on the animal, but it is the course of action and interaction that determines which ones are perceived, and for what.

The final example is about failing to keep the animals (pigs) in the right perceptual frames. In an experiment, pigs had to be attended 24 h a day by technicians (who became known as pig-sitters). Their job was to sit at a desk, two feet away from the pen in which pigs were kept, to monitor the technical equipment, to record the pigs' global activity and to keep the pen clean. Three months later, the pigs were sacrificed for additional data. In these circumstances the technicians couldn't avoid developing strong attachment to the pigs. The pigs were named after super-heroes

[6] This is what Lynch (1988) called the "biological" animal in the laboratory. He opposed it to the "analytical" animal, which is a source of reliable scientific information. In a Science and Technology Studies approach, Lynch's analysis aims at describing the process by which the analytical animal is constructed.

and the pig-sitters were sincerely fond of them. Although they tried not to develop a pet relationship with the pigs, it was impossible for the pig-sitters to see them simply as laboratory objects. Because of the intricacies of their respective lives, the pigs and their pig-sitters shared a story, they were in a dialogic relationship and the pig-sitter were affected by the pigs. With the growing familiarity, the pig-sitter's perception of their animal charge became more acute; the pig became present not as an experimental body, but as an embodied consciousness. Sacrifice, Arluke writes, "was clearly a collective trauma" (Arluke, 1988, p. 115).

## FRAGILE PERCEPTUAL FRAMES?

As the previous examples have shown, the animal's status varies enormously depending on the practical actions the human beings make them parts of. Herzog (1988) documented the case of "escaped" mice in a laboratory. The escaped mice once lived as experimental subject, but they managed to escape and since then, they live an underground life and changed status: now they are bad mice that need to be exterminated. According to Herzog, the label "good" or "bad" mouse explains why individuals of the same species receive such different treatments: while the good ones are killed with kindness, the others are cruelly trapped. In agreement with Noble (1981), I don't think that the name of a thing in and of itself causes it to be perceived in one way or another. Rather, mice change status because people act differently toward them; as escaped mice, they offer different bodily and behavioral cues, and they engage people in different actions (trap, destroy. . .) that in turn cause them to behave differently. For the pragmatist, who considers action prior to perception, the name is second: they become bad ones because they are cruelly trapped.

The observations of Fluvian (2010) may provide some additional understanding. She too has observed that mice are given several statuses (living being, preparation and sensitive being), but no name is attached to it. Interestingly, she has noted that when the mouse status changed, *the whole interactive situation changed*: the researcher's tone of voice while talking to the mouse, her facial expression, the way she handled and perceived the mouse. Again, it would be difficult to argue that the perception of the mice' mental qualities depends on an act of inference that would proceed cognitively from behavioral cues and analogical reasoning in one situation but not in another one. Objectively, it can be argued that the cues are probably present in each situation, but the practical conditions of the action and interactive settings are making them obvious (affordances) or invisible. When shifting from a detached to an engaged position, the researcher perceives or enacts another mouse.

Actually, it is well known in anthropological research that animal status can change abruptly, in a rapid process that challenges the whole definition of the situation. In many hunter-gatherer societies, ontological differences between human beings and animals are far from fixed. They are rather "chronically unstable" and require efforts (i.e., relational processes) to be both stabilized and transformed (Remme, 2016, p. 118). Even in our society, in the most "fixed" perceptual frame, as is the laboratory, it may happen that a simple "look" on an animal's face unexpectedly challenges the course of action. One laboratory studied by Arluke decided to call off one of the experiments because laboratory technicians were convinced that the dog to be sacrificed "knew what was happening" because of "something in his eyes and behavior." In one way or another, that dog managed to make his personhood perceptible in spite of the objectifying perceptual frame. It can happen that an unexpected affordance arises from a perception that is peripheral with regard to the main action and the main definition of the situation. Then, an alternative signification takes shape and the whole situation is reframed. In this case, sacrifice became murder, and the action became impossible to carry out. This is why laboratory people develop strategies to keep these competing affordances in the background of their awareness. It should be emphasized that this is a never-ending process. Cultural devices help stabilize the status of animals, but these are always provisional.

In the pragmatist view advocated here, perceptual cues, like a dog offering itself for petting, work as social affordances which invite particular kinds of behavior, and not others. According to the current action, they will be perceived or not. In any event, the interaction is the context in which mental states are perceived. It can even be argued that the perception of affordances, like the dog inviting me to stroke her, is directly linked to the apperception of mental states. As I perceive the dog's invitation to stroke her, I feel her as friendly. Maybe I'll later verbalize it as "she is kind," but it is not necessary, as I can stay in the feeling of being related to this "kind" animal. Additionally, it is misleading, as this verbalization is only a *post hoc* utterance that pretends to describe the dog while it is indeed about my feeling of the dog and my relationship with her.

## ANTHROPOMORPHISM AND IMAGINATION

Before I conclude, I'd like briefly re-examine the question of imagination in anthropomorphism. According to the pediatrician and psychoanalyst Donald Winnicott, imagination is necessary to relate oneself to something that is different from one's self. He created the concept of "intermediate area" or "potential space" to name "an intermediate area of experiencing, to which inner reality and external life both contribute" (Winnicott, 1971, 2005, p. 3). This intermediary area that could support an encounter with something very different from one's own self contains the possibility of establishing a relation with the world that does not force the individuals to choose between the inner life and the outer reality, but, quite on the contrary, enables them to connect the inside and the outside in a creative way. The example of the girl playing with a piece of wood as a baby is a good example of an experience taking place in an intermediate area. I would hypothesize that, maybe in many animal encounters, the creation of an intermediate area is the condition for people to be able to aggregate their experience and, thanks to imagination, connect the heterogeneous perceptual cues afforded by the animal's body and/or behavior, and recognize some pattern.

While the example of the girl reminds us of the potential role of imagination in anthropomorphism, the concept of intermediate area cautions us against a radical view of anthropomorphism as a pure projection of human properties onto animals. In the scope of this theory, anthropomorphism is better defined as a way to perceive/create patterns that connect people with animals and make them relevant according to the current activity. This perspective is radical in the sense that we no longer need to decide whether some features (i.e., jealousy), "really" belong to the animal behavior *or* are projected by the human observer, but instead it invites the researcher to empirically document the cultural, interactive and situational conditions in which it happens.

## CONCLUSION

This paper has shown that anthropomorphism, when it is studied in its naturally occurring circumstances, appears to be more complex than the attribution of mental or human qualities to an object, event or living being, according to a similarity gradient. As many examples have shown, anthropomorphism is not so much the product of an act of inference as it is the direct perception of human properties by someone who is engaged in a specific interaction and who accepts to let him/herself being touched or affected by the animal and its expressive qualities. Personhood is perceived rather than attributed, and it is perceived by the whole body, not only by the mind. Because the human or mental qualities are perceived from the inside of a relationship, keeping a relational point of view on anthropomorphic terms would prevent confusing them with a description of the animal "itself" while they are truly about the human–animal relationship.

From a pragmatist point of view, if it is true that animal mental qualities are discovered/produced in a specific interactional setting, it follows that any description of animal mental qualities should be accompanied by a description of its relational context of discovery. This could also be the case for the scientific inquiry in animal minds, as it has been suggested that animals are differently minded according to the interactional regime. Actually, this kind of reflexive thinking is usual in anthropology and, from a pragmatist point of view, could have its rationale in cognitive ethology too. Finally, the paper also suggests that uncertainty, imagination and illusion could be considered as important ingredients of human–animal relationships. Considered the situated perception of human and/or mental qualities, anthropomorphism appears as a powerful lens through which human–animal relationships can be studied. The perspective that has been advocated here also offers conceptual tools for in-depth ethnographic studies of anthropomorphism as a complex situated phenomenon.

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The author confirms being the sole contributor of this work and has approved it for publication.

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# Dimensional Structure of and Variation in Anthropomorphic Concepts of God

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When considering other persons, the human mind draws from folk theories of biology, physics, and psychology. Studies have examined the extent to which people utilize these folk theories in inferring whether or not God has human-like biological, physical, and psychological constraints. However, few studies have examined the way in which these folk attributions relate to each other, the extent to which attributions within a domain are consistent, or whether cultural factors influence human-like attributions within and across domains. The present study assessed 341 individuals' attributions of anthropomorphic properties to God in three domains (psychological, biological, and physical), their religious beliefs, and their engagement in religious practices. Three Confirmatory Factor Analyses tested hypothetical models of the underlying structure of an anthropomorphic concept of God. The best fitting model was the "Hierarchical Dimensions Concept," the analyses indicated one overall dimension of anthropomorphism with three sub-domains. Additionally, participants' religiosity was negatively related to attributing human-like psychological properties to God, suggesting that the more people engage with their religion, the less they think about God as having a 'human-like' mind. Religiosity was positively related to individual consistency scores in the biological domain. In other words, greater religiosity was related to less consistent answers about God's biological properties. As a result, the findings of the current study also suggest that individuals do not just vary between each other in how much they anthropomorphize God, but additionally, variation exists in the type of anthropomorphic reasoning used within an individual person's concept of God.

**Keywords: anthropomorphism, religious cognition, cognitive science of religion, religiosity, supernatural agents**

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## INTRODUCTION

The tendency for humans to anthropomorphize non-human entities across the life course has been well documented (e.g., Heiphetz et al., 2016; Nyhof and Johnson, 2017). Rather than focus on the generalized tendency to anthropomorphize non-human entities and objects by attributing to them agency and mental states, the current study examines the extent to which anthropomorphizing supernatural beings, such as God, occurs across domains and for uniquely human-like psychological processes. There is considerable evidence suggesting that applying human-like traits to non-human entities, like animals, computers, shapes, and supernatural beings, may constitute an innate cognitive bias, a bias that is common among all human minds (Guthrie, 1993; Dacey, 2017). In practice, an anthropomorphic bias leads people to make inferences about entities using their concept of "human" or "agent," rather than based on direct observable evidence from that entity (Rottman and Kelemen, 2012). Both children and adults will apply human-like traits even to geometric figures (e.g., triangles, squares) if those figures seem to move in systematized (i.e., patterned) ways (Csibra et al., 1999). Although some researchers are unpacking the nature of individual differences in the tendency to anthropomorphize (e.g., Waytz et al., 2010; Severson and Lemm, 2016), studies aiming to unpack the underlying structure of anthropomorphic concepts and relate that structure to folk reasoning in domains of psychology, physics, and biology, have been limited. The current study leverages the fact that concepts of unobservable, supernatural agents (e.g., God) are represented across human cultures and in human minds to examine the underlying dimensional structure of anthropomorphic attributions to God.

By studying how individuals make anthropomorphic inferences about unobservable, supernatural agents the current study simultaneously addresses three often understudied aspects of anthropomorphizing from the existing literature. First, the current study examines the attributions of human-like, rather than general, psychological properties to God. Although most studies of anthropomorphic reasoning consider it to be driven by folk psychological cognitive processes, anthropomorphic attributes are often conflated with attributions of agency (Epley et al., 2007). There are however, important differences between attributions of agency (self-propelled movement and having goal-directed actions) and mentality [goal-directed actions (i.e., agency) that are driven by internal thoughts, beliefs, emotions, perceptions, and desires] (Barrett, 2008); and there are further distinctions that are associated with *human-like* agency and mentalizing. However, studies that focus on the mentalizing attributions to non-human agents and objects typically focus on mental states that are also regularly associated with non-human entities (i.e., animals), such as having thoughts, desires, and perceptions (Epley et al., 2007; Shtulman and Lindeman, 2016).

Less commonly studied are inferences individuals make about whether non-human entities have *human-like* cognitions, such as the ability to pretend. Asking individuals whether they would apply specific, human-like psychological states to non-human entities can highlight the extent to which anthropomorphic reasoning about spiritual agents involves more than general attributions of agency or mentalizing, but rather attributions of *human-like* agency or mentalizing.

Second, studies of anthropomorphism must contend with the fact that anthropomorphizing involves the coordination of different inputs and cognitive processes, inputs based on direct observation or experience, in conjunction with the use of anthropomorphic reasoning. In research, the difficulty in delineating the role of anthropomorphic reasoning in concept formation arises when the information coming from these inputs overlaps. For example, a computer is a physical object that must conform to many of the same physical laws as a human body. Thus, a study that identifies that people attribute human-like physical traits to a computer would not be able to disentangle if that attribution is based in direct observation of computers conforming to physical laws, generally speaking, or to the inferences made that a computer must conform to the same physical laws as a person. Studying anthropomorphic attributions to an unobservable entity such as God, removes this confound, reflecting anthropomorphism through inference, rather than through direct experience (e.g., people cannot see if God has a body, they must infer if God has a body).

Third, studies of anthropomorphic reasoning often only assess the psychological attributions people make about non-human entities. However, humans are conceptualized as having biological and physical attributes as well. The focus on psychological attributes exclusively is due to the fact that the non-human entities examined have biological and/or physical attributes of their own, independent of any anthropomorphic inferences. For example, a person may infer that a dog needs to eat and cannot pass through walls, but that inference is not made because of any anthropomorphic reasoning. Asking individuals to make inferences about a non-human entity that does not have a corporeal form (according to religious or cultural messages) provides an opportunity to examine anthropomorphic reasoning beyond the psychological realm.

The current study of God concepts addresses each of these understudied aspects and delineates the structural nature of anthropomorphic concepts. Overall, the present study sought to determine: (a) the underlying structure of individuals' anthropomorphic concept of God, (b) whether there are cultural and experiential predictors of that structure, and (c) whether individuals are consistent in how they anthropomorphize the different sub-domains of concepts of God. To examine these research questions, the present study assessed individuals' attribution of anthropomorphic properties to God in three domains (i.e., psychological, biological, and physical), their religious beliefs, and their engagement in religious practices. Within each domain of human-like traits, participants were asked about characteristics of humans that would differentiate humans from an omniscient, omnipotent, and omnipresent explicit concept of God (e.g., humans can forget, God cannot forget). The primary contributions of the current study include an analysis of how these domains relate to one another and an exploration of the experiential (e.g., religious belief and participation) and personal (e.g., belief in God) factors that contribute to individual differences in anthropomorphizing across the three domains.

## ANTHROPOMORPHIC REASONING

According to Epley et al. (2007), there are at least three separate factors that contribute to the tendency to anthropomorphize: (a) people use concepts of agency to reason about non-human entities, (b) people are motivated to understand the behavior of non-human entities, and (c) people are socially motivated to seek social contact. The first factor, the tendency to use of concepts of agency to reason about non-human entities, is the most heavily researched, particularly in the cognitive science of religion (e.g., Rottman and Kelemen, 2012; Heiphetz et al., 2016). From this perspective, when a person is reasoning about a non-human entity, that person conceptualizes that entity as an intentional actor that wants to effect some change upon the world. A set of assumptions can follow once an entity has been characterized as an intentional actor, including the assumption that the entity has mental states (including knowledge, emotions, and/or desires) that drive actions.

However, humans are not just conceptualized as intentional actors, but also as biological entities that obey the laws of physics. When making inferences about human beings, people do not only use their folk-psychological reasoning but use their folk-biological and folk-physical reasoning as well. A concept of a human is an entity that has mental states that drive action, but also has biological processes and obeys the laws of physics. However, there is debate as to whether people make anthropomorphic inferences based solely on their folk-psychological reasoning or their concept of 'human' (Rottman and Kelemen, 2012). If people only apply their folk-psychological reasoning to non-human entities, they would only make assumptions of agency and mentality. If people use their concept of 'human,' which includes all three domains of folk knowledge, when reasoning about a non-human entity, they would also make assumptions of growth and physicality. When engaging in anthropomorphic reasoning, thinking that a dog can have human-like mental states is just as anthropomorphic as thinking that God has a biological body. However, studies have suggested there are circumstances in which people are more or less likely to apply folk-psychological reasoning or their concept of 'human' to non-human entities.

More specifically, studies have begun to document extensive variation in the ways in which people anthropomorphize. Waytz et al. (2010) examined individual differences in people's tendency to anthropomorphize, creating and validating the Individual Differences in Anthropomorphism Questionnaire (IDAQ). Using this measure, Waytz et al. (2010) found individual differences in how much people anthropomorphize non-human entities and found these differences to be stable over time. When spiritual entities were among the non-human entities participants were asked to consider, spiritual entities loaded on a separate factor than animals and non-animals (technologies). Waytz et al. (2010) primarily operationalized anthropomorphism as the extent to which people attribute mental states to non-human entities (e.g., mind, free will, consciousness). Regarding the spiritual entities in particular, participants did not discriminate anthropomorphic and non-anthropomorphic traits from each other; Waytz et al. (2010) interpreted this finding to mean the measure more likely was a measure of belief in spiritual agents rather than anthropomorphism of spiritual agents.

Without the spiritual agents, the IDAQ had two underlying factors: anthropomorphism of animals and anthropomorphism of non-animals (Waytz et al., 2010). Waytz et al. (2010) found that these two factors were related in such a way as to suggest two factors within a superordinate tendency to anthropomorphize, with animal anthropomorphizing loading more strongly than non-animal anthropomorphizing. By collapsing the two factors together for a dispositional trait measure of anthropomorphism, the researchers found that increases in anthropomorphic reasoning are related to moral judgments of non-human entities, environmental concern, and trust in technological agents (i.e., computers and robots) (Waytz et al., 2010). In other words, the more an individual anthropomorphizes an agent, the greater reported belief that the agent deserves moral regard, moral care, and is trusted. This body of work indicates that anthropomorphizing differs both by individual but also by entity (human versus different types of non-humans). Regarding spiritual entities, the conflation in the IDAQ of anthropomorphizing with belief in spiritual entities suggests individual differences in anthropomorphizing spiritual entities involves more than reasoning about just their agency.

## Anthropomorphic Reasoning About God

Although the tendency to anthropomorphize non-human entities is seen as a universal and innate behavior, an individual's cultural context influences which non-human entities are anthropomorphized and how those entities are anthropomorphized. Nowhere is this clearer than in the conceptualization of supernatural beings (Heiphetz et al., 2016). In cultures across the world, people often conceptualize supernatural beings, such as gods, spirits, and ghosts, as having minds or mental states that are similar to humans (e.g., Knight et al., 2004). A deity can have human-like emotions, a spirit can act intentionally, and a ghost can have mental limitations, such as ignorance (Nyhof and Johnson, 2017).

Given the interest in the current study on the extent to which adults make anthropomorphic inferences about God, the current study measured explicit concepts of God. However, it should be noted that people do not just anthropomorphize supernatural beings explicitly in stories or religious practices. In fact, although supernatural beings are often assigned special mental, biological, or physical properties that distinguish them from humans explicitly (i.e., consciously) (Boyer, 2001), people implicitly (i.e., non-verbally, unconsciously) conceptualize these beings as having human-like properties as well (Heiphetz et al., 2016). In other words, while adults may explicitly reason about God in non-anthropomorphic ways (i.e., God is omniscient), they may implicitly conceive of God as human-like, with human limitations and needs (Barrett and Keil, 1996; Shtulman and Lindeman, 2016).

One method for tapping into participants' implicit anthropomorphic reasoning while asking explicit questions is to ask participants to rate their certainty about whether or not God has certain human-like traits (Richert et al., 2017). For example, in a study measuring the relation between parents' anthropomorphic attributions to God and children's differentiation of God's mind and human minds, parents indicated their certainty that God had specific psychological (e.g., could forget), biological (e.g., could get sick), or physical (e.g., could get wet in the rain) limitations. Although parents globally answered no to these questions, Muslim parents were significantly more certain that God did not have these kinds of anthropomorphic traits than Protestant Christian, Roman Catholic, or Religiously Non-Affiliated parents (Richert et al., 2017).

Within the area of the cognitive science of religion, researchers have taken at least two approaches to the study of anthropomorphic concepts of the Judeo-Christian God. The first approach has been to explore how individuals conceptualize God's mind and knowledge, as compared to that of other entities (e.g., Barrett et al., 2001; Knight et al., 2004; Makris and Pnevmatikos, 2007; Lane et al., 2012; Richert et al., 2017). These studies of applying folk-psychological reasoning to concepts of God have indicated support that some (primarily Christian and Non-Affiliated) children think of God has having human-like mental states and limitations, whereas other (primarily Muslim) children do not.

The second approach has examined the degree to which individuals reason that God has human-like properties in all three folk domains: psychological, biological, and physical properties (e.g., Shtulman, 2008; Shtulman and Lindeman, 2016). Studies that examined each domain separately suggest people attribute more psychological properties to God than biological properties. Shtulman (2008) examined how adults attributed various properties to God and fictional beings (like fairies and vampires). On average, participants stated that God and the fictional beings had more psychological traits than either biological or physical traits. These findings suggest that people apply more folk-psychological reasoning to God than folk-biological or folk-physical reasoning.

Extending this research, Shtulman and Lindeman (2016) examined how adults attributed psychological and biological and physical traits to God. In their study, the psychological traits were related to agency and mentality (e.g., having beliefs, desires, intentions, emotions, and the ability to perceive). The biological traits were related to biological processes (e.g., breathing, eating, aging, becoming ill) and biological organs (e.g., heart, brain, bones). The physical traits related to existing as a physical entity in the world that was subject to the laws of physics (e.g., exerts force, has weight). Consistent with the previous findings, adults attributed more psychological traits to God than biological or physical traits. Shtulman and Lindeman (2016) noted that despite the participants not attributing many biological or physical traits to God, the mean levels were not zero. Thus, adults did utilize their folk-biological and folk-physical reasoning to conceptualize God, just not in the same way as their folk-psychological reasoning.

## The Role of Religious Belief and Experience

As noted above, anthropomorphizing of culturally specific supernatural agents should be shaped by and responsive to the cultural context (Heiphetz et al., 2016). Support for this assertion has emerged in research into the influence of belief in God and religious exposure on anthropomorphizing of God. Shtulman and Lindeman (2016) found that measures of religiosity were related to attributions of human-like properties of God. Religiosity was measured with a 16-item questionnaire on daily spirituality, positive religious coping, participation in public and private forms of worship, and self-reported religiosity. Participants who reported higher levels of religiosity also were more likely to attribute psychological and physiological properties to God (although attributions of physiological properties to God was lower than attributions of psychological properties).

The positive nature of these correlation patterns indicates potential concern about confounding participants' belief in God with attributions they make to God. For example, Willard and Norenzayan (2013) found that variation in a person's ability to reason about mental-states (i.e., theory-of-mind) was linked to belief in God. Interestingly however, belief in God was unrelated to the general tendency to engage in anthropomorphic reasoning as measured by the IDAQ. This suggests that a person does not necessarily need to believe in the existence of God in order to hold anthropomorphic concepts of God. Additionally, Waytz et al. (2010) found that measures of anthropomorphizing God that focus on attributions of agency and mentality may conflate belief in God with attributing any traits at all to God.

Studies in the development of anthropomorphizing of God have suggested that religious factors other than belief in God may additionally relate to individuals' anthropomorphizing. For example, children of parents who believed the actions of prayer serve a ritualized, communicative function were more anthropomorphic in their concepts of God than children of parents who believed that the actions of prayer were there to promote internal reflection (Richert et al., 2016).

Recent studies have also documented differences in anthropomorphic reasoning about God by religious tradition. In one study, Muslim children and parents anthropomorphized God significantly less than Protestant Christian and Catholic children and parents (Richert et al., 2016). In a study with children from Latter-Day Saints and mainstream Christian backgrounds, children demonstrated an understanding that supernatural agents like God, have special mental properties; and the religious traditions that those children were from, influenced that understanding (Nyhof and Johnson, 2017). In another study, Hindu adults were more likely than Protestant Christian adults to associate physiological traits to God (Shtulman and Lindeman, 2016). To assess the varying influences religious beliefs and practices may have on anthropomorphic reasoning about God, the current study incorporated measures of belief in God and the soul, participation in religious activities, and participation specifically in religious rituals.

# RESEARCH QUESTIONS

In summary, previous research on anthropomorphic reasoning has found that people use their concept of agency to make inferences about non-human entities (Epley et al., 2007). Between people, however, there is considerable variation in the tendency to anthropomorphize (Waytz et al., 2010; Severson and Lemm, 2016). In order to separate the role that cognitive processes and direct experience play in anthropomorphizing non-human entities, researchers have examined how people anthropomorphize God, a non-observable, non-human entity (e.g., Barrett and Keil, 1996; Barrett et al., 2001; Shtulman, 2008; Heiphetz et al., 2016;

Shtulman and Lindeman, 2016; Richert et al., 2017). Overall, studies on how people anthropomorphize God have found that people do differentiate between the mental abilities of God and human beings (Heiphetz et al., 2016). Moving beyond the psychological domain, research has also shown that people attribute more anthropomorphic psychological properties to God than biological or physical properties (Shtulman, 2008; Shtulman and Lindeman, 2016). Finally, research on the contextual factors that might predict individual differences have shown that people anthropomorphize God less when they have more religious exposure, and less when they are from the Islamic religious tradition (Richert et al., 2016, 2017). However, research has yet to fully characterize the underlying structure of anthropomorphic reasoning when it's applied to concepts of God. Thus, the current study examines (a) the conceptual structure of anthropomorphic reasoning about God, (b) predictors of that structure in individuals, and (c) consistency within and between the sub-domains of that structure in individuals.

## Conceptual Structure of Anthropomorphic Reasoning

The first research question of the current study regards the underlying conceptual structure of anthropomorphic reasoning about God in adults. Adults and children do vary in what human-like properties they attribute to different categories of non-human entities (Waytz et al., 2010; Severson and Lemm, 2016). However, researchers commonly collapse the underlying sub-categories of anthropomorphism together (e.g., animal and non-animal) to create a trait-like score of an individual's tendency to anthropomorphize. Research has yet to fully explain variation within and across dimensions of anthropomorphic reasoning.

As mentioned above, there is still debate as to whether anthropomorphic reasoning is just the application of agency and mentalizing (i.e., folk-psychological reasoning) to non-human entities, or the application of the entire 'human' concept (i.e., all three folk domains). Within concepts of God specifically, adults are more likely to attribute psychological properties to God than physical or biological properties (Shtulman, 2008; Shtulman and Lindeman, 2016). If anthropomorphic reasoning was just the application of agency and mentality, attributions of God's psychological properties would be unrelated to the attributions of God's physical and biological properties. The examination of mean differences between domains (psychology versus biology versus physics) has not outlined how or if domains relate to each other within individuals. Thus, the primary goal of the present study was to characterize the underlying structure of anthropomorphic reasoning in individual concepts of God.

To answer this question, three competing hypotheses were tested. The first hypothesis proposed that there is one overarching dimension of anthropomorphic reasoning, without sub-domains (**Figure 1**). In this structure, an individual who highly anthropomorphizes God in biological traits also would highly anthropomorphize God in psychological and physical traits. This hypothesized structure is labeled as the "One-Dimension Concept."

The second hypothesis proposed that there are three independent dimensions of anthropomorphic reasoning: psychological, biological, and physical (**Figure 2**). In this structure, an individual's anthropomorphic reasoning about God in the biological domain would be unrelated to their anthropomorphic reasoning about God in any of the other domains. This hypothesized structure is labeled as the "Independent Dimensions Concept."

The third hypothesis proposed that there is an overall dimension of anthropomorphic reasoning that is composed of three sub-domains – psychological, biological, and

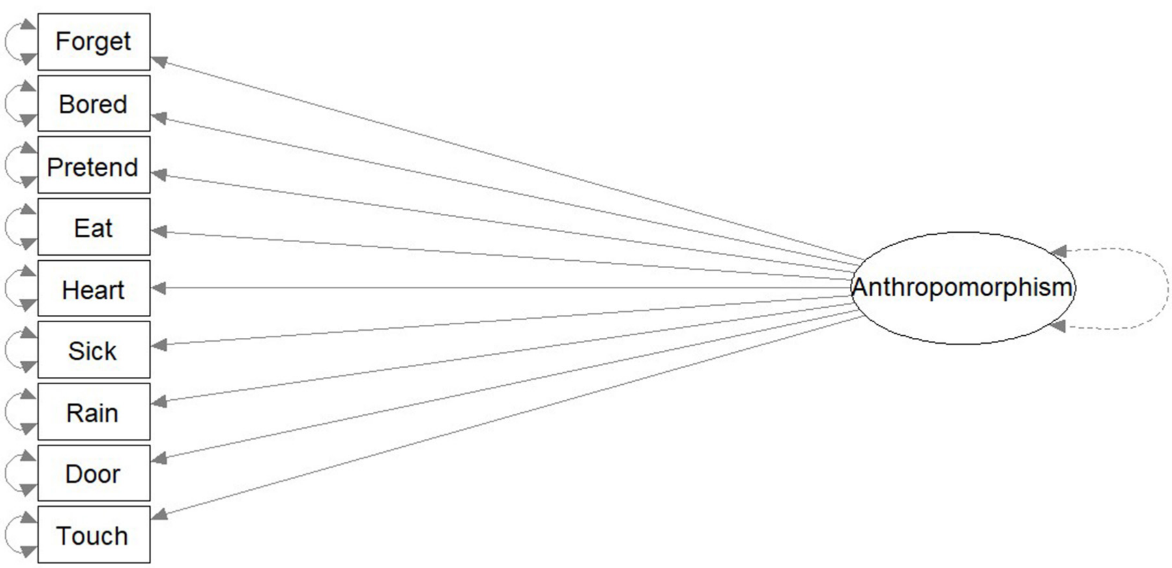


**FIGURE 1 |** "One-Dimension Concept." The "One-Dimension Concept" is a theoretical model predicting that the structure of anthropomorphism is one overarching dimension, without sub-domains.

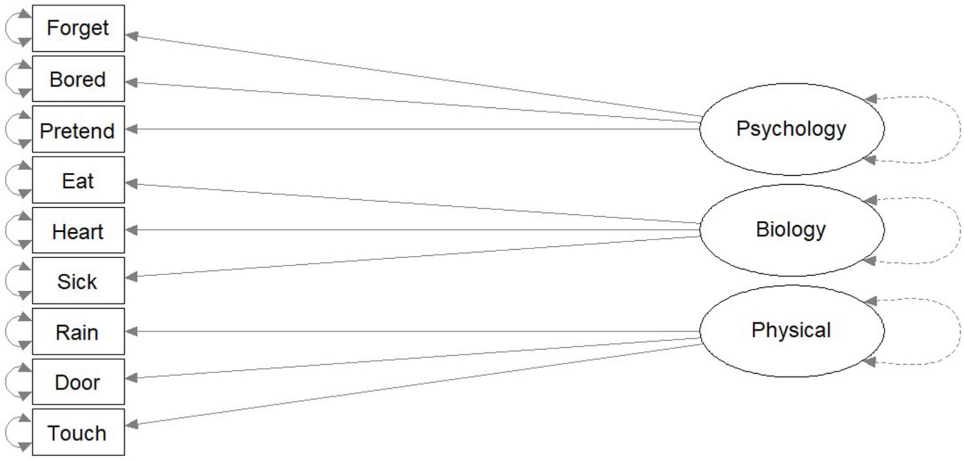


**FIGURE 2 |** "Independent Dimensions Concept." The "Independent Dimensions Concept" is a theoretical model predicting that the structure of anthropomorphism is three unrelated dimensions.

physical – each of which contributes differentially to the overall anthropomorphic concept of God (**Figure 3**). In this structure, an individual's anthropomorphic reasoning about God in one domain would be partially determined by a domain-general tendency toward anthropomorphizing God while also being independently determined by domain-specific anthropomorphizing of God along a specific dimension. This structure is labeled as the "Hierarchical Dimensions Concept."

## The Role of Religious Belief and Experience

The second research question was related to understanding what cultural inputs are potential causes of variation between and within individuals regarding their anthropomorphic reasoning about God. Some research suggests that more religious individuals attribute more anthropomorphic properties (e.g., can hear, be aware of things) to God than less religious individuals (Shtulman and Lindeman, 2016). However, other research indicates that the tendency to anthropomorphize in general is unrelated to belief in God (Willard and Norenzayan, 2013). Developmental research in children show that anthropomorphic reasoning about God is unrelated to the frequency of participation in religious practices, instead children's anthropomorphic reasoning is related to their parents' anthropomorphic reasoning (Richert et al., 2016). Thus, the present study explored whether religious behavior and/or belief was related to an individual's anthropomorphic concept of God.

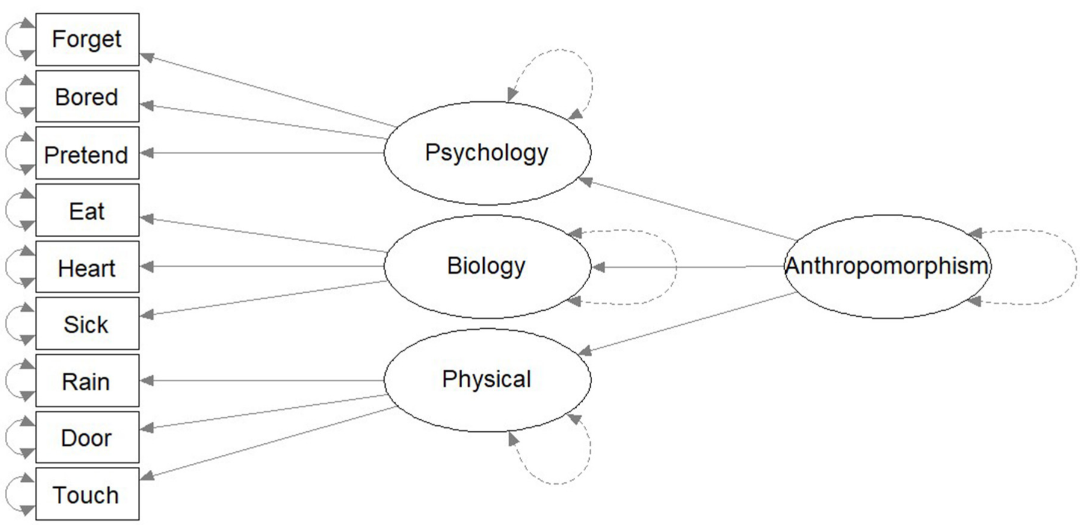


**FIGURE 3 |** "Hierarchical Dimensions Concept." The "Hierarchical Dimensions Concept" is a theoretical model predicting that the structure of anthropomorphism is one overarching domain with three sub-domains.

## Sub-domain Consistency of Anthropomorphic Attributions

The third research question was more exploratory and addressed the extent to which people's anthropomorphic reasoning varies within themselves, between domains in attributing anthropomorphic properties. In other words, people may rate God (or other non-human entities) as highly anthropomorphic across domains or may rate God as highly anthropomorphic in some domains (e.g., psychological) and not others (e.g., biological). Previous research has examined how people differ from one another in their global attributions of anthropomorphism (Waytz et al., 2010; Severson and Lemm, 2016) and in mean differences in the attribution of anthropomorphic properties in domains of anthropomorphism (Shtulman, 2008; Shtulman and Lindeman, 2016). However, it remains unclear where variation exists within people, between domains (psychological versus biological), and potentially within a single domain. Thus, the present study examined if individuals were consistent in their anthropomorphic attributions to God within each domain.

# MATERIALS AND METHODS

The present study assessed adults' anthropomorphic concepts of God, the underlying dimensional structure of anthropomorphic reasoning, predictors of the dimensional structure, and the consistency of individuals' attributions. Adults, varying in religious affiliation, indicated their certainty that God had biological, psychological, and physical attributes. Participants also answered questions about their religious behavior and religious belief.

## Participants

Three hundred and forty-one undergraduate students participated in this study. All participants were recruited through introductory psychology classes at a large university in Southern California. All participants received course credit for participation, and all participants spoke English. Participants had a range of religious affiliations (**Table 1**).

**TABLE 1 |** Age, gender, and religious affiliation of participants.

| | Gender | | |
|---|---|---|---|
| | **N** | **M** | **SD** |
| Male | 129 | 19.54 | 1.71 |
| Female | 212 | 19.49 | 1.83 |
| | **Religious affiliation** | | |
| | **N** | **M** | **SD** |
| Protestant Christian | 93 | 19.42 | 1.61 |
| Roman Catholic | 98 | 19.57 | 2.05 |
| Muslim | 34 | 19.06 | 1.07 |
| Non-Affiliated | 98 | 19.67 | 1.91 |
| Other | 18 | 19.65 | 1.27 |
| Total | 341 | 19.51 | 1.78 |

## Assessments

### Anthropomorphic Reasoning

Participants answered nine questions about the anthropomorphic properties of God. Of the nine questions, three focused on God's psychological properties, three focused on God's biological properties, and three focused on God's physical properties (see **Table 2** for exact questions). Previous research with adults and children has indicated these nine questions reliably predict anthropomorphic reasoning about God (Richert et al., 2016; Shaman et al., 2016). Participants rated their certainty that God had each of these anthropomorphic properties on a 5-point scale from "Definitely No" [−2] to "Definitely Yes" [+2]).

**TABLE 2 |** Questions assessing anthropomorphic properties of God.

| | |
|---|---|
| Psychological | Could God forget things? |
| | Could God get bored? |
| | Could God have a pretend friend? |
| Biological | Does God need to eat food and drink water? |
| | Does God have a heart that keeps God alive? |
| | Could God get sick? |
| Physical | Could God get wet when it rains? |
| | Does God have to open a door to go through it? |
| | Could you touch God with your hand? |

For each domain of anthropomorphic properties, the mean of participants' ratings was calculated. Thus, each participant had three domain average scores (psychological, biological, and physical) ranging from −2 to +2; a high score indicated the participant thought God was anthropomorphic in that domain and a low score indicated the participant thought God was non-anthropomorphic in that domain. An overall anthropomorphic reasoning score was also calculated by averaging all nine responses (**Table 3**).

For each domain of anthropomorphic properties, the standard deviation of participants' ratings was calculated. Thus, each participant had three domain consistency scores (psychological, biological, and physical); a high score indicated the participant was not consistent in attributing to God anthropomorphic properties within that domain and a low score indicated the participant was consistent in attributing to God anthropomorphic properties within that domain.

**TABLE 3 |** Anthropomorphism of God.

| | ***M*** | ***SD*** | **Cronbach's α** |
|---|---|---|---|
| Psychological | −0.53 | 1.03 | 0.655 |
| Biological | −0.64 | 1.13 | 0.799 |
| Physical | −0.38 | 1.04 | 0.655 |
| Overall | −0.52 | 0.87 | 0.828 |

An overall consistency score was also calculated (**Table 4**).

### Religious Belief

Participants answered questions about their belief in God and belief in the soul, as well as questions about how religious and spiritual they considered themselves to be. Participants indicated their certainty that God and the soul existed on a 5-point scale from "Definitely does not exist" [−2] to "Definitely does exist" [+2]. Overall, participants were somewhat certain that God existed and that the soul existed (**Table 5**). Participants also indicated how religious and spiritual they considered themselves to be compared to the average American on a 5-point scale from "Not at all" [1] to "Very" [5]. Overall, participants considered themselves about average on religiosity and spirituality.

### Religious Behavior

Participants answered three questions about the frequency of their religious behavior: attendance at events sponsored by a religious organization (e.g., youth group), engaging in private religious practices (e.g., prayer), and participation in public religious practices (e.g., religious services). Participants rated the frequency of participation on a 9-point scale from "Never" [0] to "Multiple times a day" [8]. These scores were averaged for an overall religious behavior variable. Overall, religious behavior was low, around 'multiple times a year' (**Table 6**).

### Religious Experiences

Participants also answered questions about their experiences with specific religious activities, rituals, and events. For each event, participants indicated if they experienced it, prayed or observed someone praying during the activity, attended a religious institution for that activity, whether a religious figure was present, and whether they learned about the activity's meaning. For each aspect of each activity, participants indicated "yes" [1] or "no" [0]. For each question type, the sum of all experiences was calculated (**Table 7**).

Christian, Catholic, and Non-Affiliated participants responded to 20 activities: Baptism, Christmas, Communion, Easter, Funerals, Lent, Marriage, Pentecost, Last Rites, Bible Study, Confession, Confirmation, Eucharist, Gospel Singing, the Lord's Prayer, Missionary work, Ordination, the Rosary, making a Pilgrimage, and Speaking in Tongues. Muslim participants responded to 20 different activities: Aqiqa/circumcision, Eid Adha, Eid Fitr, Eid Mubahila, Eid Zehra, Jumah (Friday) Prayer, Muharram/Ashura, Mahe Ramadhan, Wiladat/Shahadat, Qur'an recitation, Namaz/Salah, fasting, Hajj/Umrah, Ziyarat, learning Arabic, attending madressah/Sunday school, learning Fiqh and Hadith, majalis/matam, dua recitation, and praying tasbeeh.

**TABLE 4 |** Consistency of anthropomorphism ratings.

| | *M* | *SD* |
|---|---|---|
| Psychological | 0.84 | 0.71 |
| Biological | 0.62 | 0.71 |
| Physical | 0.83 | 0.73 |
| Overall | 1.00 | 0.53 |

**TABLE 5 |** Religious belief.

| | *M* | *SD* |
|---|---|---|
| Belief in God | 0.99 | 1.19 |
| Belief in the soul | 1.33 | 0.82 |
| Religiosity | 2.84 | 1.13 |
| Spirituality | 3.11 | 1.14 |

**TABLE 6 |** Frequency of religious behavior.

| | *M* | *SD* | Cronbach's α |
|---|---|---|---|
| Events | 2.29 | 1.98 | |
| Public practices | 1.96 | 2.04 | |
| Private practices | 2.84 | 2.81 | |
| Religious behavior | 2.36 | 1.98 | 0.82 |

## Procedure

Participants answered the survey electronically over the internet. Participants answered questions about their anthropomorphic concept of God first, followed by the questions about their religious beliefs and behavior. The survey took participants 38.5 min on average to complete.

# RESULTS

## Conceptual Structure of Anthropomorphic Reasoning

The first research question was about the underlying structure of an individual's anthropomorphic concept of God. Three confirmatory factor analyses (CFA) were conducted to test the three competing hypotheses. For each CFA model, the nine questions assessing different anthropomorphic properties of God were entered as the observed variables (see **Table 8** for correlations between observed variables). Models were estimated using maximum likelihood estimation. Additionally, for each model, the variances of the latent factors were set to 1. Factor loadings were then standardized.

When fitting data to a model in a CFA, a comparative fit index (CFI) greater than or equal than 0.95, a root mean square error of approximation (RMSEA) less than 0.08, and a standardized root mean square residual (SRMR) less than 0.08 indicate that the model acceptably fits the data (Schreiber et al., 2006). When fit to the data, the one-dimension model did not meet acceptable standards, $\chi^2(27) = 144.64$, $p < 0.001$,

**TABLE 7 |** Sum of religious experiences.

| | *M* | *SD* | Cronbach's α |
|---|---|---|---|
| Experienced | 9.83 | 5.08 | 0.89 |
| Prayed | 9.54 | 5.76 | 0.92 |
| Religious institution | 8.99 | 5.80 | 0.92 |
| Religious figure | 9.36 | 6.00 | 0.93 |
| Meaning | 10.97 | 5.93 | 0.93 |

**TABLE 8 |** Correlations between anthropomorphic properties of God questions.

| Properties | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1. Forget | – | | | | | | | | |
| 2. Bored | 0.38** | – | | | | | | | |
| 3. Pretend | 0.29** | 0.50** | – | | | | | | |
| 4. Eat | 0.32** | 0.25** | 0.34** | – | | | | | |
| 5. Heart | 0.20** | 0.22** | 0.32** | 0.57** | – | | | | |
| 6. Sick | 0.39** | 0.37** | 0.45** | 0.63** | 0.53** | – | | | |
| 7. Rain | 0.26** | 0.29** | 0.41** | 0.50** | 0.44** | 0.55** | – | | |
| 8. Door | 0.28** | 0.24** | 0.34** | 0.62** | 0.47** | 0.54** | 0.57** | – | |
| 9. Touch | 0.04 | −0.01 | 0.13* | 0.26** | 0.30** | 0.19** | 0.32** | 0.29** | – |

**$p < 0.05$, ***$p < 0.01$.

CFI = 0.847, RMSEA = 0.113, SRMR = 0.071. When fit to the data, the independent model did not meet acceptable standards, $\chi^2(27) = 397.842$, $p < 0.001$, CFI = 0.638, RMSEA = 0.201, SRMR = 0.274. When fit to the data, the hierarchical model did meet acceptable standards, $\chi^2(24) = 73.086$, $p < 0.001$, CFI = 0.952, RMSEA = 0.077, SRMR = 0.051.

An additional way to assess model fit is to compare models to each other rather than assessing if each model meets acceptable standards. When using Akaike information criterion (AIC), smaller values indicate the model fits the data better than larger values (Schreiber et al., 2006). Not only was the "hierarchical dimensions concept" model the only one to acceptably meet the fit criteria, when using a comparative fit statistic, the hierarchical model (AIC = 9543.567) fit the data better than the one-dimension model (AIC = 9609.125), which fit the data better than the independent model (AIC = 9862.323).

The findings from the three CFA analyses support the "hierarchical dimensions concept" hypothesis. In other words, when individuals conceptualize God's anthropomorphic properties, they conceptualize the psychological, biological, and physical properties differently from one another; however, each sub-domain of properties is influenced by superordinate anthropomorphic reasoning about God.

### Sub-domain Analysis

Given the data suggest the hierarchical dimensions model best fit the data, a deeper examination of the sub-domains and the relations between them was warranted. As seen in **Table 9**, the CFA indicated the biological sub-domains loaded more strongly onto the latent construct of anthropomorphic reasoning about God than the psychological and physical sub-domains.

For further exploration, a Repeated-Measures ANOVA was conducted examining mean differences between the domains (see **Table 3** for means and standard deviations). There was a significant effect of sub-domain, $F(2, 680) = 10.018$, $p < 0.001$, $\eta_p^2 = 0.029$. Participants did not rate God's psychological properties different than God's biological properties [$t(340) = 1.770$, $p = 0.78$, $\eta_p^2 = 0.012$]. However, participants did rate God as more anthropomorphic in the physical domain than in the psychological [$t(340) = 2.390$, $p = 0.038$, $\eta_p^2 = 0.013$] and biological [$t(340) = 5.223$, $p < 0.001$, $\eta_p^2 = 0.075$] domains.

The analyses of participants' attributions of anthropomorphic properties to God revealed three primary findings. First, within a concept of God, anthropomorphic reasoning exists as latent, hierarchical construct consisting of three sub-domains: biological, psychological, and physical. Second, participants are more likely to infer God has physical anthropomorphic properties to God than psychological or biological properties. Third, participants' attribution of biological properties to God contributes more than attributions in other sub-domains to an individual's overall anthropomorphic concept of God. Because the hierarchical structure of anthropomorphic reasoning in this case (e.g., concept of God) emerged, further analyses examined predictors of variation in participants' anthropomorphic reasoning within the three sub-domains.

## The Role of Religious Belief and Experience

The second research question asked whether religious behavior and/or belief was related to an individual's anthropomorphic concept of God. A series of correlations were conducted to assess how participants' belief, religious behavior, and religious experiences, were related to their mean levels of

**TABLE 9 |** Unstandardized and standardized coefficients for hierarchical dimensions model.

| Observed variables | Latent construct | β | B | SE |
|---|---|---|---|---|
| Forget | Psychological | 0.52 | 0.51 | 0.07 |
| Bored | Psychological | 0.67 | 0.66 | 0.07 |
| Pretend | Psychological | 0.68 | 0.71 | 0.07 |
| Eat | Biological | 0.08 | 0.80 | 0.58 |
| Heart | Biological | 0.07 | 0.67 | 0.51 |
| Sick | Biological | 0.08 | 0.80 | 0.52 |
| Rain | Physical | 0.42 | 0.74 | 0.09 |
| Door | Physical | 0.45 | 0.79 | 0.10 |
| Touch | Physical | 0.23 | 0.37 | 0.06 |
| **Predictors** | | | | |
| Psychological | Anthropomorphism | 0.89 | 0.67 | 0.12 |
| Biological | Anthropomorphism | 12.90 | 0.99 | 89.44 |
| Physical | Anthropomorphism | 2.08 | 0.90 | 0.53 |

anthropomorphic reasoning and their mean levels of each sub-domain of anthropomorphic reasoning (**Table 9**).

First, a 3 × 4 Repeated-Measures ANOVA was conducted examining the mean differences between the sub-domains, as a within-subjects variable, and religious affiliation as a between-subjects variable. For this analysis, participants who listed 'Other" were removed from the analysis due to the small number of participants. There was a significant main effect of domain, $F(2, 638) = 7.660$, $p = 0.001$, $\eta_p^2 = 0.023$. Again, participants rated God as more anthropomorphic in the physical domain than the psychological and biological domains. There was also a significant main effect of affiliation, $F(3, 319) = 11.067$, $p < 0.001$, $\eta_p^2 = 0.094$. Bonferroni *post hoc* tests indicated that Protestant Christian and Muslim participants significantly anthropomorphized God less than the Roman Catholic and Non-Affiliated participants. Finally, there was a significant interaction between domain and religious affiliation, $F(6, 638) = 8.811$, $p < 0.001$, $\eta_p^2 = 0.077$.

Follow-up one-way ANOVAs were conducted to compare religious affiliations among each domain (**Figure 4**). For the psychological domain, the affiliations did significantly differ, $F(3, 319) = 14.441$, $p < 0.001$, $\eta_p^2 = 0.120$. Bonferroni adjusted *post hoc* tests indicated Non-Affiliated participants anthropomorphized God significantly more than the other three religious affiliations. Roman Catholic participants did not differ from Protestant Christians but did anthropomorphize God significantly more than Muslim participants. For the biological domain, the affiliations did significantly differ, $F(3, 319) = 9.135$, $p < 0.001$, $\eta_p^2 = 0.079$. Bonferroni adjusted *post hoc* tests indicated Roman Catholic participants anthropomorphized God significantly more than Protestant Christian and Muslim participants, but not Non-Affiliated participants. No other significant differences existed among religious affiliations. For the physical domain, the affiliations did significantly differ, $F(3, 319) = 7.790$, $p < 0.001$, $\eta_p^2 = 0.068$. Bonferroni adjusted *post hoc* tests indicated Muslim participants anthropomorphized God significantly less than all other religious affiliations. Roman Catholic participants anthropomorphized God significantly more than Non-Affiliated participants.

In summary, Muslim participants anthropomorphized God less than participations from other religious backgrounds. Regarding the relations of the domains to each other, participants had strongest anthropomorphic reasoning about God in the physical domain, but patterns of psychological and biological anthropomorphic reasoning differed by religious background. Among Protestant Christian, Muslim, and Non-Affiliated participants, God was anthropomorphized least in the biological domain, with anthropomorphic reasoning in the psychological domain falling between the physical and biological domains. However, for the Roman Catholic participants, God was anthropomorphized least in the psychological domain, with the biological domain between the psychological and physical domains.

Beyond identification with a specific religious affiliation, a pattern emerged in how participants' religious behavior and belief were related to their anthropomorphic reasoning about God (**Table 10**). No significant correlations emerged between participants' biological or physical anthropomorphizing and their beliefs or experiences. However, participants who had higher levels of belief in God and the soul, reported stronger religiosity and spirituality, greater frequency of religious behavior, and

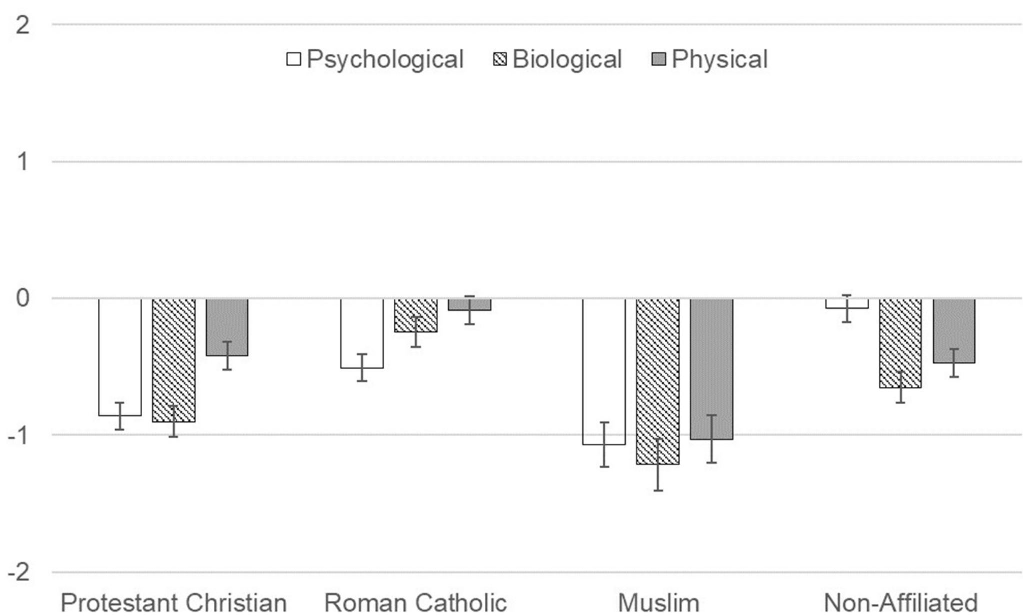


**FIGURE 4 |** Anthropomorphism of God by sub-domain and religious affiliation. Mean levels of anthropomorphic attributions to God within each sub-domain separated by religious affiliation.

**TABLE 10 |** Correlations between anthropomorphism and religious belief and behavior variables.

| | Psychological | Biological | Physical | Overall |
|---|---|---|---|---|
| Belief | | | | |
| God | −0.35** | −0.08 | −0.05 | −0.19** |
| Soul | −0.35** | −0.13* | −0.10 | −0.23** |
| Religiosity | −0.29** | 0.01 | 0.04 | −0.09 |
| Spirituality | −0.29** | −0.07 | 0.00 | −0.14** |
| Behavior | −0.39** | −0.17** | −0.11* | −0.27** |
| Religious experiences | | | | |
| Experience | −0.21** | 0.01 | 0.01 | −0.08 |
| Observe | −0.25** | −0.02 | 0.02 | −0.10 |
| Attend | −0.24** | −0.01 | 0.01 | −0.10 |
| Religious figure | −0.20** | −0.01 | 0.03 | −0.07 |
| Learned meaning | −0.21** | −0.05 | −0.02 | −0.11* |

*$p < 0.05$, **$p < 0.01$.

greater frequency of participation in religious practices were less likely to anthropomorphize God in the psychological domain.

Thus, the present study added evidence to support the hypothesis that religious beliefs and behavior are related to participants' anthropomorphic reasoning of God (Shtulman and Lindeman, 2016). However, the findings are more nuanced. Religious beliefs and experiences are specifically related to how participants conceptualized the psychological properties of God, but not God's biological and physical properties.

## Sub-domain Consistency of Anthropomorphic Attributions

The third research question asked whether individuals were consistent in their anthropomorphic attributions to God within each domain. A Repeated-Measures ANOVA was conducted to determine if participants differed in how consistent they were in their anthropomorphic attributions of God between each domain. Additionally, a series of correlations were conducted to assess how participants' belief, religious behavior, and religious experiences were related to their consistency of anthropomorphism scores.

First, a 3 × 4 Repeated-Measures ANOVA was conducted examining the consistency of responses within each sub-domain, as a within-subjects variable, and religious affiliation as a between-subjects variable. For this analysis, participants who listed 'Other" were removed from the analysis due to the small number of participants. There was a significant main effect of domain, $F(2, 638) = 9.822$, $p < 0.001$, $\eta_p^2 = 0.030$. Participants were more consistent (i.e., varied less) in their responses in the biological domain than the psychological [$t(340) = 4.601$, $p < 0.001$, $\eta_p^2 = 0.059$] or physical domains [$t(340) = 4.209$, $p < 0.001$, $\eta_p^2 = 0.052$]. Participants did not differ in their consistency within the psychological or physical domains [$t(340) = 0.149$, $p = 0.88$, $\eta_p^2 < 0.001$].

As with mean levels of anthropomorphic reasoning in the different sub-domains, there was also a significant main effect of affiliation, $F(3, 319) = 7.849$, $p < 0.001$, $\eta_p^2 = 0.069$. The nature of this interaction, however, was different than that for mean levels. Bonferroni *post hoc* tests indicated that Protestant Christian and Roman Catholic participants were significantly less consistent in their attributions of anthropomorphic properties than Muslim and Non-Affiliated participants (**Figure 5**). Finally, there was no significant interaction between domain and religious affiliation, $F(6, 638) = 1.553$, $p = 0.158$, $\eta_p^2 = 0.014$.

As seen in **Table 11**, a pattern emerged in how participants' religious behavior and belief were related

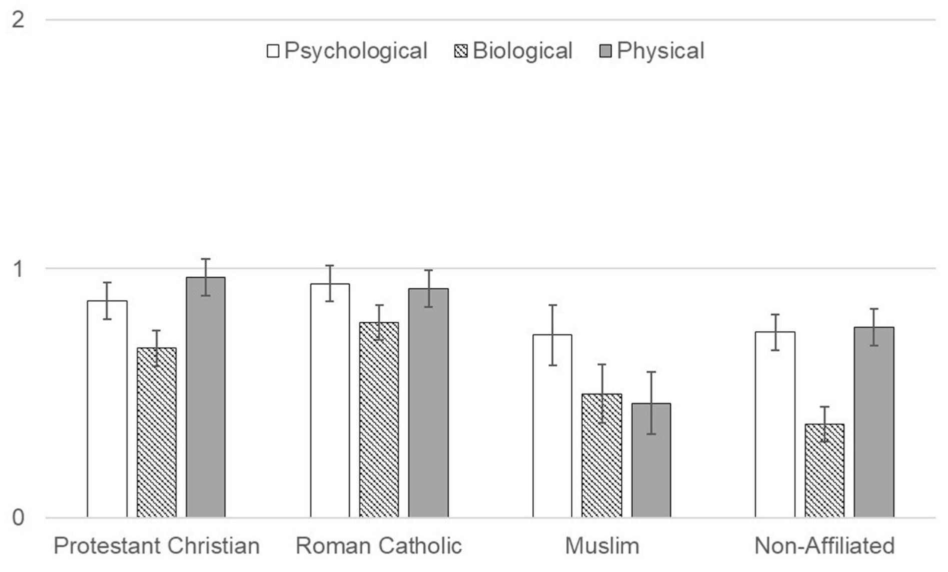


**FIGURE 5 |** Consistency of anthropomorphism of God by sub-domain and religious affiliation. Consistency of anthropomorphism attributions to God within each sub-domain separated by religious affiliation.

**TABLE 11 |** Correlations between consistency of anthropomorphism and religious belief and behavior variables.

| | Psychological | Biological | Physical | Overall |
|---|---|---|---|---|
| Belief | | | | |
| God | 0.11* | 0.19** | 0.03 | 0.18** |
| Soul | 0.09 | 0.16** | 0.14* | 0.21** |
| Religiosity | −0.08 | 0.14** | 0.02 | 0.09 |
| Spirituality | −0.02 | 0.13* | 0.04 | 0.11* |
| Behavior | −0.05 | 0.13* | 0.01 | 0.07 |
| Religious experiences | | | | |
| Experience | 0.03 | 0.15** | 0.04 | 0.11 |
| Observe | 0.02 | 0.14* | 0.03 | 0.10 |
| Attend | 0.02 | 0.12* | 0.04 | 0.10 |
| Religious figure | 0.05 | 0.13* | 0.02 | 0.11 |
| Learned meaning | 0.04 | 0.14* | 0.07 | 0.15 |

*$p < 0.05$, **$p < 0.01$.

to their consistency in anthropomorphizing God that was different from the pattern with mean levels of anthropomorphic reasoning. Participants who had higher levels of belief/religiosity, as well as higher levels of religious behavior and experiences, were less consistent in how they anthropomorphized God in the biological domain. These possible predictors of variation in participants' anthropomorphic reasoning of God were unrelated to participants' consistency in the psychological and physical domains.

Thus, the present study indicated that the biological sub-domain had greater consistency as compared with the other domains; and the consistency of the biological sub-domain was related to individuals' religious beliefs and experiences.

## DISCUSSION

The present study sought to determine the underlying structure of the anthropomorphic concept of God, whether religious belief and/or religious behavior were related to that structure, and whether individuals were consistent in their anthropomorphic concept of God. Participants indicated their certainty that God had nine anthropomorphic properties that fell within three sub-domains: biological, psychological, and physical. Participants also provided details about their religious beliefs and behavior. Confirmatory factor analyses were conducted to assess the structure of the anthropomorphic concept of God, and correlations and Repeated-Measures ANOVAs were conducted to assess which predictors were associated with participants' anthropomorphism of God. Findings are discussed as they relate to the specific research questions regarding: (a) the conceptual structure of anthropomorphic reasoning about God, (b) predictors of variation in individuals' anthropomorphic reasoning about God, and (c) individual consistency of anthropomorphizing within biological, psychological, and physical domains.

### Conceptual Structure of Anthropomorphic Reasoning

In order to address the first research question, which asked about the underlying structure of an individual's anthropomorphic concept of God, three hypotheses were proposed. The "One Dimension Concept" hypothesis suggested that there was one overall dimension of anthropomorphic reasoning that dictated how a person viewed all of God's anthropomorphic properties. The "Independent Dimensions Concept" hypothesis suggested that there were three independent domains of anthropomorphic reasoning and how an individual viewed God's anthropomorphic properties in one domain was unrelated to the other domains. The "Hierarchical Dimensions Concept" hypothesis suggested that there was one overall dimension of anthropomorphic reasoning with three sub-domains and how an individual viewed God's anthropomorphic properties in one domain was both related to an overall concept of anthropomorphic reasoning as well as an individual concept in that domain.

Three CFAs were conducted testing each hypothesis and the data fit the hierarchical model the best supporting the Hierarchical Dimensions Concept hypothesis. This finding suggests that when individuals anthropomorphize God, they make domain-specific inferences about God's psychological, biological, and physical properties, but each domain is additionally influenced by an overarching concept of anthropomorphism that causes the domains to relate to one another.

One possible interpretation of this finding is that people may use their overall concept of 'human' to reason about God rather than just their concepts of agency and mentalizing. If people only used folk-psychological reasoning in their concept of God, then the psychological domain would be the primary, if not only, contributor to their overall anthropomorphic concept of God. Instead, the results of the CFA suggested that people's biological concept of God contributed most strongly their overall anthropomorphic concept of God. One thing to consider is that by merely asking participants about God's psychological, biological, and physical traits, we prime them to use those domains of folk reasoning to answer the questions in the way that they did (i.e., this is a methodological artifact). However, the existence of a super-ordinate dimension that caused each of the sub-domains to be related to one another suggests that the more likely explanation is that people do apply their concept of 'human' to God.

To some extent, these findings also further support those of Waytz et al. (2010) and Shtulman and Lindeman (2016), in that both studies demonstrated evidence of dispositional or trait-level differences in anthropomorphizing. The fact that, in this study, the underlying dimensions of psychological, biological, and physical attributions all contributed to the same latent construct indicate that there is a general tendency toward or against anthropomorphizing that contributes to an individual's attribution of anthropomorphic traits to God in all three domains.

However, the current findings also extend both Waytz et al. (2010) and Shtulman and Lindeman's (2016) findings in meaningful ways. Waytz et al. (2010) indicated the

IDAQ resulted in three constructs (animals, non-animals, and spiritual beings). In regards to animals and non-animals, participants readily distinguished the anthropomorphic and non-anthropomorphic characteristics (Waytz et al., 2010). However, participants responded similarly to the anthropomorphic and non-anthropomorphic characteristics of spiritual beings. Waytz et al. (2010) suggested that anthropomorphic responses about spiritual beings reflected belief in or recognition of spiritual beings, rather than anthropomorphic reasoning. The finding in the present study that belief in God was related to psychological attributions to God, not biological or physical attributions, suggests that participants' anthropomorphic attributions to God (or other spiritual beings) may not serve as a proxy for belief, but may instead reflect domain-level distinctions in which human-like characteristics God does and does not have. This interpretation is further supported by the fact that Waytz et al. (2010) asked participants about attributions of mentalizing and agency but did not inquire about biological or physical attributions.

The findings regarding the sub-domains of anthropomorphism also may appear to contrast with Shtulman and Lindeman (2016), particularly in the fact that Shtulman and Lindeman (2016) found participants indicated God had more psychological anthropomorphic attributes than physiological attributes. In contrast, participants in the current study indicated God had more physical anthropomorphic attributes than biological or psychological attributes. One reason for the difference may be that Shtulman and Lindeman (2016) combined biological and physical attributes into an overall physiological domain. An additional reason for the difference may be the current study assessed psychological anthropomorphic properties in a different way. Shtulman and Lindeman (2016) assessed psychological attributes that closely matched the basic concepts of agency and mentalizing, including properties of beliefs, desires, intentions, emotions, and perceptions. However, the current study assessed psychological attributes that were more human-like. Given that the current study looked at more uniquely human attributes, participants may have been less likely to apply them to God. In other words, individuals may be more likely to attribute agency-related psychological attributes to God than human-related psychological attributes to God.

These findings suggest the importance of differentiating general attributions of agency from more specific attributions of humanness in studies of anthropomorphism. The current study was not designed to test between these forms of anthropomorphism, but the hierarchical structure of anthropomorphism to God suggests two possibilities. One possibility is that the hierarchical structure of anthropomorphism of God reflects the logical, structural relation between the three domains of folk knowledge. An individual's use of their folk psychological reasoning may trigger their use of folk biological and folk physical reasoning. If an entity has mental states, then it carries that the entity also has a biological and physical body to support those mental states. In the case of the current study, the latent construct of overall anthropomorphic reasoning would then reflect the expression of this inference. If individuals attribute any psychological properties to God, they would be more likely to attribute biological and physical properties as well.

A more likely possibility, given the overall patterns in the results, is that participants used their concept of 'human' and of human limitations to reason about all aspects of God, hence the latent anthropomorphic domain was that of 'human.' In particular, participants inferred human-like physical characteristics to God more than psychological characteristics. Additionally, the biological domain loaded more strongly on the superordinate domain than the psychological domain. When reasoning within these domains, then, participants likely were relying on their concept of 'human' to make inferences about God; the concept of 'human' would then lead to reasoning in each of the folk domains, hence the sub-domains in the model.

## The Role of Religious Belief and Experience

The second research question asked whether an individual's anthropomorphic concept of God was related to their religious beliefs, behavior, and/or experiences. Participants' self-reported religious beliefs, behaviors, and experiences were correlated with their attributions of anthropomorphic properties to God in each sub-domain. Overall, participants' religious beliefs, behaviors, and experiences were significantly and negatively related to their anthropomorphic concept of God in the psychological domain, but not the biological or physical domains. When participants believed in God and the soul, had higher religiosity and spirituality, engaged in more religious behaviors, and had more religious experiences, they attributed less anthropomorphic psychological properties to God. In other words, when participants were more engaged in their religion overall, they did not think of God as having human-like psychological characteristics. These findings are in contrast with those of Shtulman and Lindeman (2016), who found that religiosity was positively related to an anthropomorphic concept of God. As discussed above, the different results may be due to the differences in how the psychological properties of God were assessed, and due to the fact that Shtulman and Lindeman (2016) combined the biological and physical domains.

The interactions between domain and religious affiliation further indicate that anthropomorphic reasoning about God exists along related but different dimensions. As in previous studies, participants who affiliated with Islam were less likely than other participants to anthropomorphize God (Richert et al., 2017). Additionally, Protestant Christian, Muslim, and Non-Affiliated participants had lowest anthropomorphic reasoning in the biological domain, with anthropomorphic reasoning in the psychological domain falling between the physical and biological domains. In contrast, the Roman Catholic participants had lowest anthropomorphic reasoning about God in the psychological domain.

The relationship between religious beliefs and experiences and anthropomorphic reasoning about God provides further support for the "Hierarchical Dimensions Concept" model discussed above. If individuals only had one overall anthropomorphic concept of God, then their religious beliefs and experiences would be related to all of the attributes of God. However, as described above, biological, psychological, and physical inferences represent distinct sub-domains of anthropomorphic reasoning. In the current study, engagement in religion was only related to psychological anthropomorphic reasoning, suggesting that concepts of God's agency or psychological anthropomorphic reasoning overlap strongly with belief in God (i.e., Waytz et al., 2010). Understanding psychological anthropomorphic reasoning as a distinct, yet related dimension of anthropomorphism is further supported by findings indicating the social-cognitive nature of religious cognition (Richert and Smith, 2009; Rottman and Kelemen, 2012). Research on prayer (Spilka and Ladd, 2013; Shaman et al., 2016), rituals (Richert, 2006; Watson-Jones and Legare, 2016), and afterlife beliefs (Bering et al., 2005) has found evidence that reasoning about these religious concepts utilizes an individual's social cognition. Social cognition refers to the aspects of cognition dedicated to how humans understand themselves and other agents in the context of a social environment; and so the connection between these cultural phenomena and social cognition suggests that cultural inputs would more strongly influence thinking about the *mind* of God (i.e., utilizing social cognition and folk psychology) as opposed to the biological and physical aspects of God's body (i.e., physical and biological cognition).

The findings of the current study suggest there are unique differences in how people reason about the biological and psychological properties of God. The biological sub-domain contributed the most strongly to the superordinate anthropomorphism concept, offering further support for the hypothesis that the latent anthropomorphism construct is more strongly related to anthropomorphizing based in 'humanness' rather than 'agency.'

## Sub-domain Consistency Anthropomorphic Reasoning

The "Hierarchical Dimensions Concept" is further supported by findings regarding different levels of consistency in the different domains of anthropomorphizing God. Consistency in item ratings was lower in the biological sub-domain than in the physical and psychological sub-domain. Additionally, although consistency did not vary by religious affiliation, participants' religious beliefs, behaviors, and experiences were significantly and positively related to their consistency in anthropomorphizing God in the biological domain, but not the psychological or physical domains. When participants believed in God and the soul more, had higher religiosity and spirituality, engaged in more religious behaviors, and had more religious experiences, they were less consistent in thinking about the biological properties of God. In other words, when participants were more engaged in their religious overall, they were more variable in how they thought about the human-like biological properties of God. As with the mean levels of anthropomorphic reasoning, if individuals only had one overall anthropomorphic concept of God then religious beliefs and experiences would be related to consistency in all three domains. The differences in consistency, however, suggest that distinct sub-domains of anthropomorphic reasoning exist.

## Developmental Implications

The current findings point to the need for research into the development and coordination of hierarchical anthropomorphic reasoning in concepts of God. Concepts of God do not emerge spontaneously in adulthood, and children tend to anthropomorphize God in general, more than adults do (Shtulman, 2008; Richert et al., 2016). Reasoning about God, including in some cases the attribution of anthropomorphic psychological, biological, and physical properties, begins as early as 3 or 4 years old (Lane et al., 2012; Richert et al., 2016). However, recent findings indicate children's anthropomorphism of God differs by religious tradition; as with the current study with Muslim adults, Muslim children did not attribute physical, biological, and psychological human-like traits to God (Richert et al., 2016).

Additionally, theoretical debates exist as to whether younger children do or do not anthropomorphize God's mind (Barrett and Richert, 2003; Lane and Harris, 2014; Richert et al., 2017). Early in development, children tend not to differentiate the mental abilities of God and human beings. But as children grow older, the difference between the two types of minds increases; God is conceptualized as less and less constrained by the limitations that the human mind has. Recent findings suggest the ages at which children differentiate God's mind from human minds (Richert et al., 2017) and whether children attribute human-like limitations to God's mind at some developmental time period (Lane et al., 2014) are related to children's religious context and their parents' beliefs.

Examining children's tendency to anthropomorphize non-human entities, Severson and Lemm (2016) adapted the IDAQ for use with children. The IDAQ-CF modified the questions in the original questionnaire to be comprehensible to young children and found a similar factor structure and individual differences among children. Overall, children were more likely to anthropomorphize animals than non-animal entities. And while there were no overall age trends, older children were more likely to anthropomorphize animals than younger children. Other developmental research has explored the sociocultural influences on anthropomorphizing God and differentiating God's mind from humans' minds; influences such as what religious tradition the individual is being raised in, their level of religious exposure, and their parents beliefs about God (Richert et al., 2016, 2017).

The current study helps to shed light on two debates in developmental research on anthropomorphic concepts of God, that of: (a) the underlying nature of children's supernatural concepts, and (b) the influence of sociocultural factors on children's anthropomorphic concepts. Two of the central findings in this study–that there is one overall dimension of anthropomorphic reasoning with three sub-domains (i.e., Hierarchical Dimensions), and that religious beliefs and behaviors are related to the psychological sub-domain of anthropomorphic reasoning but not the other two sub-domains–provides direction for future developmental research. Future research should explore whether and how the underlying dimensional structure of anthropomorphic concepts of God changes across development; and at what point in development those religious factors become more or less relevant to reasoning about God.

### Limitations and Future Directions

The current study has certain limitations which suggest directions for future research. One potential limitation in the study was the relative narrow way in which anthropomorphic reasoning about God was assessed. Participants indicated their certainty that God was anthropomorphic in only nine properties. This assessment is a possible reason for the discrepancy between the results of the current study and those of Waytz et al. (2010) and Shtulman and Lindeman (2016). For example, psychological attributes in previous research were strictly related to a general concept of agency, while the attributes in the present study were related more to the specific a concept of 'human.' Future research should include a wider range of anthropomorphic properties that assesses both concepts of agency and 'human' to see where differences may lie.

A second limitation was the size of the sample. While the sample had an appropriate size for the Repeated-Measures ANOVA analyses and correlations, the size only just met what was necessary for simple CFAs. A more in-depth analysis of the hierarchical structure was not possible without more participants. In particular, a larger sample size would have been better able to address if the conceptual structure differed by religious affiliation or other cultural context variables. Future research should continue to explore the underlying structure of anthropomorphic reasoning and determine if it varies by any other meaningful religious context or cognitive variables. For example, the findings of the present study suggest that Muslim and Non-Affiliated participants are the most consistent in how they conceptualize God's anthropomorphize properties. A CFA with a larger sample size can assess whether Muslim and Non-Affiliated participants attribute anthropomorphic properties to God using the "Hierarchical Dimensions Concept" or perhaps one of the other models.

## CONCLUSION

The findings of the present study suggest that individuals have an anthropomorphic concept of God that is hierarchical and composed of three sub-domains. A concept of God is influenced by an overall anthropomorphic concept and separately influenced by sub-domains of anthropomorphic reasoning (i.e., psychological, biological, and physical). For example, when a person thinks about God's mental properties (i.e., God can forget something), they make inferences based upon two concepts: a superordinate anthropomorphic concept and a subordinate psychological anthropomorphic concept. But when that same person thinks about God's biological properties (i.e., God can get sick), they make inferences based upon the same superordinate anthropomorphic concept, but a different subordinate concept, biological anthropomorphism.

The presence and use of these sub-domains is important because they are differentially affected by people's cultural environments. When a person engages more in their religion, they also think of God less anthropomorphically in the psychological domain. But when a person engages more in their religion, they are less consistent in thinking about God's anthropomorphic properties in the biological domain. The implication is that when studying the tendency to anthropomorphize non-human entities and what influences that tendency, researchers must look deeper. Individuals do not just vary between each other in how they anthropomorphize God but vary within themselves as well.

## ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the UCR Human Research Review Board. The protocol was approved by the UCR Human Research Review Board. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

## AUTHOR CONTRIBUTIONS

NS conducted the analyses and wrote significant portions of the introduction, methods, and results section. All authors equally contributed to the introduction and discussion sections. All authors contributed to the writing of the article and editing of the article.

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REVIEW
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# Seeing More Than Human: Autism and Anthropomorphic Theory of Mind

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Theory of mind (ToM) is defined as the process of taking another's perspective. Anthropomorphism can be seen as the extension of ToM to non-human entities. This review examines the literature concerning ToM and anthropomorphism in relation to individuals with Autism Spectrum Disorder (ASD), specifically addressing the questions of how and why those on the spectrum both show an increased interest for anthropomorphism and may even show improved ToM abilities when judging the mental states of anthropomorphic characters. This review highlights that while individuals with ASD traditionally show deficits on a wide range of ToM tests, such as recognizing facial emotions, such ToM deficits may be ameliorated if the stimuli presented is cartoon or animal-like rather than in human form. Individuals with ASD show a greater interest in anthropomorphic characters and process the features of these characters using methods typically reserved for human stimuli. Personal accounts of individuals with ASD also suggest they may identify more closely with animals than other humans. It is shown how the social motivations hypothesized to underlie the anthropomorphizing of non-human targets may lead those on the spectrum to seek social connections and therefore gain ToM experience and expertise amongst unlikely sources.

**Keywords: anthropomorphism, autism, theory of mind, social cognition, perspective taking, mentalizing, animals**

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## INTRODUCTION

*It took me a long time to figure out that I see things about animals other people don't. And it wasn't until I was in my forties that I finally realized I had one big advantage over the feedlot owners who were hiring me to manage their animals: being autistic. Autism made school and social life hard, but it made animals easy (Grandin and Johnson, 2009, p. 1).*

Anthropomorphism is the ascription of human features to non-human entities (Epley et al., 2007), and it often occurs when non-human entities are perceived as behaving both intentionally and unpredictably (Waytz et al., 2010b). Perhaps one reason individuals are more likely to anthropomorphize entities that are unpredictable is that human behavior can be equally difficult to predict, governed by a complex system of non-observable cognitions, beliefs, and motivations (Evans and Stanovich, 2013). Luckily, early in life we learn to attend to nuances in behavior that allow for an intrinsic tracking of other's intentions (Onishi and Baillargeon, 2005). Thus, when non-human entities behave invariably, we reflexively attempt to make sense of that behavior, by tracing it back to a particular goal or purpose.

The act of delineating a person's goal or purpose involves using theory of mind (ToM). ToM is a form of social cognition that refers to the ascription and recognition of thoughts, emotions and beliefs to the self and others and the ability to recognize that another's perspective is different from our own (Baron-Cohen, 1999). When people ponder the goals or motivations of non-human entities, they are essentially using ToM. Humanizing the behavior of non-human entities is a pathway toward using ToM to understand the entity's motivations or intentions, thus anthropomorphism and ToM are closely connected (Epley et al., 2007). Areas of the brain such as the temporoparietal junction (TPJ), which activates in accordance with ToM, also activates when anthropomorphizing (Chaminade et al., 2007) and when rationalizing the behavior of both humans and animals (Spunt et al., 2017). Additionally, the more a person anthropomorphizes, the larger the areas of the brain that are responsible for ToM processing (Cullen et al., 2014), highlighting the connection between anthropomorphism and ToM.

There is some evidence that ToM and, by association, anthropomorphism, reflect a more general predictive strategy people use to process unpredictability in the environment, independent of any one agent's human-like properties, called predictive encoding (Friston and Frith, 2015). For instance, in the "uncanny valley," when a stimuli is presented as human, such as a humanoid robot, yet their behavior is *too* predictable or mechanical, numerous error signals are transmitted, and as a result it is difficult to predict the robot's actions (Saygin et al., 2012). Thus, at its most basic level, it is likely that ToM, and in turn anthropomorphism, is triggered through a more general recognition of behavioral patterns through a process of predictive encoding.

However, it is also true that anthropomorphism is not simply the mind engaging in more general predictive strategies, but involves applying a specifically human schema to better understand non-human agents. This process can be observed when individuals take the Social Attribution Task, in which people increasingly attribute human behavioral patterns to animated shapes (Heider and Simmel, 1944). By humanizing non-human agents, individuals are better equipped to utilize familiar predictive encoding strategies. As people have extensive knowledge of the types of goals that underlie such behaviors in human agents, the more one humanizes for example an unpredictable gadget, the easier it becomes to predict the gadget's future behavior (Waytz et al., 2010b). This helps explain why, in contrast, dehumanizing an agent, such as the robot in the "uncanny valley," leads to particularly strong predictive encoding disruption (Saygin et al., 2012).

Arguably the largest store of knowledge about human agency comes from an understanding of one's own behavioral antecedents and outcomes, which can aid in the representation of what may underlie a person's actions. Humphrey (1984) refers to this as "reflexive consciousness" or the ability to map the externalizing behaviors of others onto the internal experience of the self. Evidence for reflexive consciousness within the brain has come through the discovery of a mirror neural network, which elicits the activation of one's own motoric brain regions even when only passively viewing the actions of others (Kohler et al., 2002), as well as a "default network" in cortical midline structures of the brain, which activates in relation to both self-related and socially related thoughts (Uddin et al., 2007). Both networks reveal the important role self-conceptualization plays when both processing other's actions and representing their mental states.

Therefore, it is likely that one reason people anthropomorphize is that they are not only "humanizing" an unfamiliar agent, but more specifically they are *personalizing* the agent to activate self-representations and simulate the other's experience. Thus, it is not surprising that a critical effect following ToM and anthropomorphic engagement with another includes perceiving that agent as more similar to the self (Epley et al., 2007), in addition to viewing them more empathically (Waytz et al., 2010a), and displaying a greater desire to interact with them in socially desirable ways (Waytz et al., 2010a). As we develop expertise in using ToM to predict the actions of others, and even ourselves, we become most capable of understanding non-human agents by attributing human motivations to their behaviors, therefore giving rise to anthropomorphism (Waytz et al., 2010b). But what if a person does not develop such an interest and expertise in human cognition? What if they struggle to self-reference? Can they anthropomorphize?

Such questions are particularly pertinent with regard to autism spectrum disorder (ASD), a condition in which affected individuals show, in comparison to those who are neurotypical (NT), deficits in ToM (Baron-Cohen et al., 2015; Kana et al., 2015), poor self-referential cognition (Lombardo et al., 2007), decreased mirror neural activity (Oberman et al., 2005) and weakened connections within the default network (Weng et al., 2010), all of which are mechanisms conjectured to play an intrinsic role in anthropomorphizing. As will be explored throughout this review, despite these differences, which would presumably contribute to a particularly weakened ability to anthropomorphize, individuals with ASD appear to display an affinity for anthropomorphism and an even stronger performance on ToM tasks when agents are non-human. Explanations for relative strengths within this population in relation to the processing of anthropomorphic ToM will be discussed.

## AUTISM SPECTRUM DISORDER

ASD is a neurodevelopmental disorder that affects approximately 1 in 68 individuals Christensen et al. (2016). Those affected possess atypical social and communicative styles, and restricted, repetitive behaviors and interests (American Psychiatric Association, [APA], 2013). Some believe that these two symptoms are somewhat separable (Brunsdon and Happé, 2014), as individuals with ASD often have significant variation in symptom profiles (Geschwind and Levitt, 2007). There are several prominent theories commonly used to explain the mechanisms believed to underpin ASD. Among them are the Empathizing/Systemizing theory (Baron-Cohen, 2009), the Enhanced Perceptual Functioning theory (Mottron et al., 2006), and the Social Motivation theory (Chevallier et al., 2012). These three theories largely center upon the hypothesized mechanisms which underlie the social and perceptual differences found in ASD, each will now be briefly explored.

The Empathizing/Systemizing theory of ASD is comprised of two elements; an empathetic/ToM deficit and a penchant toward systematic stimuli conforming to rule-based logic, such as numbers or mechanical objects (Baron-Cohen, 2009). Evidence of empathy deficits within ASD include cognitive difficulties such as failure to pass false belief tasks (Baron-Cohen et al., 1985), and affective impairments such as reduced ability to process facial emotions (Baron-Cohen et al., 2001), or poor automatic tracking of non-verbal cues (Schuwerk et al., 2015).

The systemizing element of the theory refers to the ability to understand and use rule-based reasoning or logic, which Baron-Cohen (2009) connects with an increased competence those with ASD often demonstrate in domains such as science and mathematics. However, as understanding social systems requires more "gestalt" or holistic interpretations, a penchant for systemizing may impede development in other areas. Indeed, research suggests that tendencies toward empathizing and systemizing have a strong inverse relationship in clinical samples (Grove et al., 2013), indicating that those with ASD may be approaching empathy tasks systematically. However, as will be highlighted in this review, several studies show those on the spectrum do not have a global deficit toward empathizing, as this theory suggests, and this ability is intact when social stimuli is anthropomorphic rather than human.

Enhanced Perceptual Functioning Theory (EPF) (Mottron et al., 2006) argues that people with ASD can indeed process globally, even at times showing strengths relative to controls (Perreault et al., 2011). However, it is hypothesized that the heightened perceptual sensitivities to lower order stimuli demonstrated by superior visual acuity (Gliga et al., 2015), sensitivity to musical pitch (Bonnel et al., 2003), motion perception (Foss-Feig et al., 2013) and even tactile sensitivity (for a review see Ben-Sasson et al., 2009), may lead to significant processing differences which may have downstream effects. For instance, as those with ASD show a diminished sensitivity to complex stimuli (Bertone et al., 2005; Boer et al., 2013) it may be that they increasingly rely on their enhanced lower-level sensory perception and thus struggle updating their processing strategies (Zaidel et al., 2015).

Heightened discriminatory abilities in relation to low-level object features in a domain (i.e., pitch, letters, digits or 2-D visuo-perceptual properties), may also underlie the circumscribed interests (CIs) in relation to a defined class of units often found to exist in this population (Baron-Cohen et al., 2009). CIs in ASD have been found to be particularly intense, interfering, and idiosyncratic compared to NTs (Anthony et al., 2013). The role of CIs in ASD with regards to processing advantages and disadvantages are themselves somewhat paradoxical in this population. For one, a person with ASD's exposure to areas related to CIs can in many instances lead to "savant" type abilities in which a person shows extreme talent in relation to knowledge of a particular domain (Happé and Frith, 2010). However, research indicates that the presence of CI related stimuli can divert attention from social stimuli, and increase perseverative behaviors (Sasson et al., 2008). Some research indicates that in certain situations, such as when both a NT peer and child with ASD are interacting in relation to the child's CI, such as playing with a toy boat or plane, social initiation is enhanced (Boyd et al., 2007). Children with ASD have also been shown to be more likely to follow another's social gaze when directed toward CI stimuli (Thorup et al., 2017). This indicates that while CIs can divert social attention in this population, they can also be mechanisms for inducing positive social behaviors.

It has also been conjectured that the heightened sensory perception, and the presence of CIs, may carry a specifically social cost to those with the condition (Unruh et al., 2016). The Social Motivation Theory (SM) of ASD (Chevallier et al., 2012), argues that the population's empathy and perceptual differences may arise through a reduced neurohormonal "reward" typically experienced when interacting socially with others (Chaminade et al., 2015a). Instead, stimuli representing restricted interests have been shown to activate reward circuitry usually stimulated through social contact (Grelotti et al., 2005; Foss-Feig et al., 2016).

While causality is difficult to infer, those that prescribe to a "social first" model of ASD believe that the enhanced ability to discriminate lower level stimuli may in part develop due to an absence of typical social development, such as the ability to engage in joint attention (Mundy et al., 2009). As young children with ASD are impaired in joint attention in the first years of life (Charman, 2003), and as joint attention is thought to underlie ToM (Sodian and Kristen-Antonow, 2015), it may be that lower level perceptual strengths develop in place of skills such as ToM which develop through more social learning methods.

Subsequent difficulties with skills like ToM have been shown to longitudinally impair social functioning and peer relations (Banerjee et al., 2011), and thus poor ToM may negatively influence a person with ASD's motivation later in life to engage in social interactions. Research indicates that adults with ASD, have been shown to experience increased rates of loneliness, depression and anxiety, and cite social reasoning difficulties as a significant source of their isolation (Jobe and Williams White, 2007). Thus, an aspect of SM theory involves the possibility that decreased social reward processing may be in part a downstream consequence of the negative social experiences those with ASD symptoms often endure (Wood and Gadow, 2010).

Both the increased salience of lower level stimuli, particularly those that align with circumscribed interests (CI), and the decreased salience of non-systematic, social stimuli that may impact social motivation (SM), could help explain why people with ASD often have difficulties using ToM, which necessitates gestalt processing through complex modalities (for instance nonverbal body language coupled with explicit vocal communication), and socially directed attention (Frith and Frith, 2006). As ToM deficits have been shown to persist throughout development (Schneider et al., 2013) and correspond heavily to ASD symptom severity (Hoogenhout and Malcolm-Smith, 2017), it is an important mechanism for understanding ASD symptomology and trajectory. As research indicates that current ToM interventions demonstrate poor transfer into real life settings (Marraffa and Araba, 2016), finding ways in which ToM may be intrinsically rewarding to those with ASD, such as through anthropomorphism, could be a vital tool for researchers and community stakeholders alike. The ability and affinity to anthropomorphize in those with ASD will be explored in relation to the above theories throughout the remainder of this review.

## ANTHROPOMORPHISM AND ASD

There is some evidence that people with ASD, despite ToM deficits in relation to human stimuli, have intact or even enhanced ToM processing in relation to anthropomorphic stimuli, a claim which will be explored in more detail in subsequent sections. Theoretically, there are several reasons why such improvements may exist, and these will be discussed in connection with the three tenants of anthropomorphism from the Epley et al. (2007) model.

In the first tenet of the Epley et al. (2007) anthropomorphism model it is stated that individuals are more likely to anthropomorphize when they have an increased motivation for sociability. Support for this comes from research showing individuals with increased levels of loneliness are more likely to anthropomorphize pets (Epley et al., 2007), robots (Lee et al., 2006), and even smart phones (Wang, 2017). Research indicates that people with ASD are particularly vulnerable to loneliness and thus the anthropomorphizing of non-human agents may function as a social outlet of sorts. For instance, adults with a high degree of ASD related traits were found to be no different than controls in their desire for companionship, but reported significantly higher ratings of loneliness which they attributed to their lack of social understanding (Jobe and Williams White, 2007). Evidence of fewer social networks (Mazurek, 2014), along with an increased perception of the self as a poor social actor (Vickerstaff et al., 2007) may contribute to the elevated levels of social anxiety present within the population (for a review see MacNeil et al., 2009). As social differences may isolate those with ASD from peers and/or result in negative outcomes, anthropomorphizing non-human entities may allow for social engagement with less emotional risk. In this way, interactions with anthropomorphic characters may become more socially motivating, in line with SM theory.

In the second Epley et al. (2007) tenet, individuals are found to increasingly anthropomorphize a non-human entity to increase efficacy, and a desire for efficacy is heightened when the non-human's behavior is increasingly unpredictable. One reason why individuals with ASD may increasingly anthropomorphize to increase efficacy is that properties of non-human creatures may map onto CIs, and are thus intrinsically rewarding to those with the condition (Dichter et al., 2010). Indeed, there have been several reported cases of children with ASD having restricted interests in relation to cartoons and animals (Grelotti et al., 2005; South et al., 2005; Turner-Brown et al., 2011), and in this way anthropomorphism may stem from a desire to increase efficacy in their restricted area of expertise. Additionally, the exaggerated physical appearance and motion of animals (Borgi and Cirulli, 2016) and cartoons (Rhodes et al., 1987) may heighten the perception of unpredictability in such agents, which leads to a desire for increased efficacy. Conversely, more nuanced behavioral cues indicating unpredictability when in human form, such as subtle changes in facial expression or gaze direction, may be more easily overlooked by those with ASD (Rump et al., 2009).

Lastly, in the third tenet, it is suggested that anthropomorphism is enhanced through the elicitation of agent knowledge, which often includes perceiving similarities between the self and the other. Individuals with ASD have been shown to have a diminished physical sense of self (Lombardo et al., 2010), and are also less sensitive to the physical irregularities of non-human agents (Kuriki et al., 2016; Kumazaki et al., 2017). Thus, it may be that a diminished physical sense of self allows individuals with ASD to view themselves in less human and more anthropomorphic ways, a viewpoint suggested in experiential accounts by those with the condition (Prince-Hughes, 2004). Thus, the increased social processing of anthropomorphic versus human agents in socially typical ways may reflect an elicitation of personal knowledge in relation to non-human entities through a processing of the self as "other than human" (Bergenmar et al., 2015).

To assess these claims, research investigating elements of social processing in individuals with ASD regarding human versus anthropomorphic stimuli will be explored. Processing of anthropomorphic versus human face and motion processing will first be discussed. Secondly, this review will explore how increased engagement with anthropomorphic stimuli can lead to ToM gains, along with a discussion of ASD interventions utilizing anthropomorphic engagement through animal and cartoon-based interventions. Finally, possible explanations for enhanced anthropomorphic interest, engagement, and social processing will be presented along with implications for practitioners and future research directions.

## ANTHROPOMORPHIC VERSUS HUMAN FACE PROCESSING

In this section, two one of the underlying mechanisms for understanding ToM, face processing and attention to eye gaze, will be examined. Aspects of face processing that differ in NTs and those with ASD are first discussed, along with the possible mechanisms driving these differences. Next, several studies are presented that demonstrate intact face processing in this population in relation to anthropomorphic characters, specifically cartoons, androids, and animals. Explanations for this differential processing are discussed along with implications for understanding ToM in this population.

## TYPICAL VERSUS ATYPICAL FACE PROCESSING

One of the integral components of ToM is conjecturing what a person is thinking by processing what their face is expressing (Baron-Cohen and Cross, 1992). It is thought that individuals begin to hone this ability immediately following birth, as infants are particularly interested in protofaces, or indistinct face-like shapes (Johnson et al., 1991), and can immediately mimic facial expressions (Meltzoff, 1999). However, prolonged exposure to familiar faces as "special" stimuli are likely responsible for the preference young children develop toward species-specific faces (Sugita, 2008), which in time develops into an expertise for species-specific facial recognition and facial emotion processing (Scherf et al., 2007).

Infants at risk for ASD have been shown to also orient toward faces, contrary to popular conceptions of ASD stemming from a nascent decreased social interest (Elsabbagh et al., 2013). Interestingly, de Klerk et al. (2014) found that at 7 months of age, infants at risk for ASD spent longer than is typical gazing at faces, yet surprisingly this was longitudinally linked to poorer facial recognition abilities. Thus, it was conjectured that the prolonged gazing at faces in infants at risk for ASD reflected piece-meal rather than holistic processing, meaning that rather than processing faces as "special" stimuli, they may have been processing them more in line with detailed objects. This may explain why NT children at age two have been found to be better able to differentiate human versus monkey faces, yet children with ASD do not develop this ability until 3–4 years of age (Chawarska and Volkmar, 2007). These differences suggest that while young children with ASD may gaze for longer at faces, they are not processing faces in a way that leads to typical facial recognition gains, which itself relies on holistic processing (Richler et al., 2011b). However, as will be discussed, it may be that those with ASD have developed an ability to process anthropomorphic faces in typical ways, which has implications for elucidating the social processing mechanisms in this population.

## HOLISTIC ANTHROPOMORPHIC FACE PROCESSING

It is conjectured that aspects of ToM depend on the ability to holistically process faces, allowing people to rapidly detect what may be a nuanced change in facial expression and to recognize familiar agents. To achieve this, individuals are thought to holistically compare a person's face with a facial prototype, which allows for the distinct properties of a face to become salient (Farah et al., 1998). A significant body of research suggests that individuals with ASD show both qualitative and quantitative differences in the way they holistically process human faces (Tang et al., 2015). For instance, in a study by Pavlova et al. (2017), individuals with ASD were asked to process images of food which were arranged to look like faces. Unlike typically developed individuals, those with ASD showed significant difficulty recognizing that the food was arranged to look like a face, indicating a detailed, piece-meal interpretation of the stimuli.

One method for measuring holistic face processing is to measure the facial inversion effect, which refers to the significant difficulty NTs display when processing inverted rather than upright faces (Leder and Bruce, 2000), indicating disruption when a face does not conform to its typical configural pattern (Richler et al., 2011a). Research indicates that individuals with ASD show a decreased inversion effect when viewing human faces (Falck-Ytter, 2008; Senju et al., 2008; Vida et al., 2013). However, there are several studies indicating that individuals with ASD may demonstrate the inversion effect when faces are anthropomorphic, indicating that they are processing them holistically.

For instance, an investigation by Rosset et al. (2008) tested facial emotion recognition in children with ASD and NT controls using both cartoon drawings and human photographs of inverted and upright faces. They found that NT children showed the inversion effect for both cartoon and human faces, meaning that their holistic facial representations were significantly disrupted when both types of stimuli were inverted. However, individuals with ASD did not show this effect when viewing inverted human faces; instead, they demonstrated the inversion effect only when processing cartoon faces.

Interestingly, follow up research by Rosset et al. (2010) again tested the inversion effect in cartoon versus human faces, but this time participants were asked to discriminate facial features of stimuli. Results showed that NT participants demonstrated the inversion effect only when viewing human faces. In contrast, participants with ASD did not show a preference for either real or cartoon faces, performing equally in each condition, and showing a reduced inversion effect compared to controls. Together, these results illustrate a trend in which anthropomorphizing social stimuli can at times be advantageous for those with ASD. While anthropomorphism does not always lead to processing gains, as shown in Rosset et al. (2010), non-human presentation does not appear to interfere with ASD processing patterns.

As individuals with ASD have been shown to report a heightened engagement with cartoons (Kuo et al., 2014), it may be that the cartoon rather than human inversion effect reflects a greater degree of elicited agent knowledge in relation to this kind of stimuli. For instance, research indicates that the inversion effect is significantly strengthened when individuals view faces reflective of their own age and race (Ding et al., 2014), indicating that elicited agent knowledge enhances the anthropomorphism of similar facial stimuli. Additionally, the lack of inversion effect toward human faces may reflect a decreased anthropomorphizing of human faces, possibly due to a decreased ability to elicit agent knowledge in relation to humans. This is surprising, as individuals with ASD undoubtedly have significantly more experience with humans. However, as the Epley et al. (2007) model also posits, a desire for sociality interacts with the elicitation of agent knowledge. Thus, it may be that decreased salience for human faces, due to a possible social disengagement with human faces, does not interfere with cartoon processing. In the following section, research in ASD demonstrating intact processing of anthropomorphic rather than human faces will be discussed in relation to neural evidence.

## FUSIFORM FACE AREA (FFA)

One mechanism implicated in the holistic processing of faces is an acquired activation in the fusiform face area (FFA) when viewing facial stimuli. The FFA is a brain region located in the right hemisphere, where "holistic" processing is thought to occur, and this region is notably activated when NT individuals view faces (Carlei et al., 2017). However, as shown in research testing individuals with particular areas of expertise, it can also activate when a person views various non-face stimuli of significant personal interest and experience (Tarr and Gauthier, 2000). Evidence will now be discussed which shows activation in the FFA in response to anthropomorphic rather than human stimuli, which provides further evidence that individuals with ASD may have differentially developed anthropomorphic rather than human expertise.

Research on brain regions such as the fusiform gyrus (FG), which houses the FFA, indicates that the development of facial expertise develops over time. For instance, in children ages five to eight the FG has been shown to be sensitive to objects, but not faces; however, this pattern reverses by the time children reach 11–14 (Scherf et al., 2007). By early to mid-adolescence, the volume of the FG has significantly increased, and this volume is correlated with a person's ability to recognize and remember faces (Golarai et al., 2007). It is thought that the developed activation of the FG, and in particular the FFA, in response to faces corresponds to an increased necessity to sensitively processing facial information, leading adolescents and adults to become face reading "experts" (Gauthier et al., 2000b). This is significant regarding ToM, as a developed expertise in facial recognition allows for nuanced interpretations when reading emotional expressions (Schmitgen et al., 2016). Individuals with ASD have been shown to demonstrate hypoactivation in the FG and FFA when looking at specifically human faces (Dawson et al., 2005; Humphreys et al., 2008; Pierce and Redcay, 2008). However, the volume of the FG in individuals with ASD is not smaller than NT counterparts, which implies that alternative stimuli may instead activate this region (Whyte et al., 2016).

It may be that FG activity is less impaired, or even intact, in individuals with ASD when social stimuli are anthropomorphic rather than purely human, particularly when stimuli represent a restricted interest. Grelotti et al. (2005) measured FFA activation in a child and adolescent with ASD, one with a heightened interest in the cartoon Digimon, and one without, along with a NT child. During a visual recognition task, participants were shown pictures featuring familiar human faces, unfamiliar human faces, cartoon characters from the show Digimon, and common objects. While the NT participant experienced activation in the FFA only when viewing human faces, the participant with ASD who watched Digimon showed FFA activation only when viewing pictures of Digimon. The participant with ASD without a preference for Digimon showed hypoactivation in the FFA when viewing both faces and Digimon, and instead showed the greatest amount of activation when viewing common objects. This suggests that familiar stimuli related to restricted interests may preferentially recruit the FFA in individuals with ASD, in contrast to human facial stimuli.

Interestingly, research testing ASD participant responses to non-familiar anthropomorphic faces, which may have been, at best, only tangentially related to restricted interests, have also been shown to elicit FFA activation. Jung et al. (2016) measured the neural responses of children with ASD and controls when viewing unfamiliar robot and human faces. Researchers were interested in examining whether robot or human stimuli activated the left hemifield of the brain, where the FFA is located. Results showed that control subjects showed increased activation when gazing at both human and robot faces, indicating activation in the FFA. In contrast, children with ASD only showed left hemifield activity when looking at robot faces and showed hypoactivation in response to human faces.

Whyte et al. (2016), measured FFA activation when adolescents with ASD and controls viewed images of unfamiliar human faces, unfamiliar animal faces (cats and dogs), and common objects. NT participants showed equal activation of the FFA when looking at human and animal faces, in line with research which suggests that in the NT population, human and animal faces are processed similarly (Schirmer et al., 2013). In contrast, those with ASD showed significant hypoactivation when processing human faces. However, those with ASD showed equivalent FFA activation for animal faces, in line with controls, and neither group showed activation when viewing objects. These findings were surprising considering research indicating aberrant gaze behaviors (Guillon et al., 2014) and poor emotional recognition (Gross, 2004) in young children with ASD when viewing both human and animal faces, and activation only in response to common objects when an item is not a specific restricted interest (Grelotti et al., 2005).

All three of these studies may offer support for the role of CIs in ToM for those with ASD, which contends that atypical stimuli may elicit activation in the brain typically reserved for social processing. For instance, the findings produced by Grelotti et al. (2005), which showed FFA activation in response to a preferred cartoon, could be seen as evidence that in ASD the FFA is engaged by restricted interests rather than faces. Similarly, increased FFA activation toward robot faces shown in Jung et al. (2016) may also reflect a heightened response toward a restricted interest, as individuals with ASD have been shown to have a fascination with mechanical systems (Baron-Cohen et al., 2009).

However, FFA activation in response to unfamiliar animal faces, as demonstrated by Whyte et al. (2016) and to a certain extent the unfamiliarity with the robot faces present in Jung et al. (2016), are not as easily explained by CIs. For one, in the Grelotti et al. (2005) study, participants were shown either human faces or whole-body representations of Digimon characters. In contrast, in both Jung et al. (2016) and Whyte et al. (2016) only facial stimuli was visible to participants. Thus, the whole-body details visible to the participant in Grelotti et al. (2005) could have led to increased focus on tertiary aspects of the cartoon that were of restricted interest. The focus on facial stimuli only in Jung et al. (2016) and Whyte et al. (2016), however, limited the ability for participants to focus on aspects of the stimuli that may form a restricted interest category (mechanics, animals) which suggests that activation occurred in response to what were specifically faces. Furthermore, in contrast to one participant's known interest and familiarity with the Digimon stimuli used by Grelotti et al. (2005), the images used in the other studies were unfamiliar to participants. As evidence suggests that only items relating to specific restricted interests elicit affective neural responses in those with ASD (Cascio et al., 2014), the decreased likelihood that the participants in each of the two study samples possessed a restricted interest underlying their engagement with the animal or robot faces presents an alternative to the CI account.

Together, these studies provide some evidence that individuals with ASD may typically process anthropomorphic rather than human faces, and that the mechanisms underlying this processing be may not be entirely attributable to CIs. This is of interest when forming accounts of ASD, as it suggests that the FFA can be recruited toward general facial processing in this population, particularly when they take a non-human form. This may stem from a possible negative association toward specifically human faces, which has ties to SM. More broadly, these studies also form implications for accounts of anthropomorphism, as it is commonly assumed that anthropomorphism extends from a primarily human representation (Waytz et al., 2010b). In individuals with ASD however, it appears that anthropomorphism occurs in spite of despite a disengagement with human representations. With regard to the third tenet of anthropomorphism by Epley et al. (2007), this may mean that the anthropomorphizing of non-human faces, indicative of facial recognition related FG activity, better elicits agent knowledge in this population. In other words, individuals with ASD increasingly anthropomorphize when agents are human-like and are less inclined to anthropomorphize agents that are strictly human, possibly indicating a closer identification with anthropomorphic creatures.

## EYE GAZE

It is hypothesized that while the holistic processing of faces is a fundamental aspect of facial recognition (Gauthier et al., 2000a), it is the changeable interior aspects of the face may be the most informative of a person's mental state (Hoffman and Haxby, 2000). Eyes are arguably the most important facial features used for both mental state interpretation (Peterson and Eckstein, 2012) and are particularly implicated in facial recognition (Schyns et al., 2002).

Individuals with ASD have been shown to display marked differences in their attention to eyes compared to NT counterparts, which may be a crucial element of subsequent ToM impairments. For instance, studies have shown that individuals with ASD spend significantly less time attending to eyes when looking at faces (Riby and Hancock, 2009), and attend more to lower regions of the face, such as the mouth (Jones et al., 2008). Both tendencies are often cited as factors leading to their reduced ability to read emotions in eyes (Baron-Cohen et al., 2001; Senju and Johnson, 2009). Researchers such as Tanaka and Sung (2016) have put forth the "eye avoidance" theory of ASD, in which they posit that a lack of eye gaze is due to a heightened emotional arousal in response to eyes. Support for this theory can be found in Kliemann et al. (2012), who showed that individuals with ASD did not simply display an increased fixation toward lower facial elements such as the mouth, but rather an increased avoidance of eyes.

It is also hypothesized that a reduced oxytocin neurohormonal release in response to human co-actors in individuals with ASD (Chaminade et al., 2015a) may make eye contact too sensitizing, as one of the purposes of oxytocin is to reduce anxiety during social engagement (Kosfeld et al., 2005). As research has also found that an administration of oxytocin attenuates neural reactivity when viewing eyes with threatening expressions (Kanat et al., 2015), and promotes eye gaze in individuals with and without ASD (Auyeung et al., 2015), it may be that those with the condition possess weakened neurohormonal priming networks which make eye contact both efficient and rewarding.

Critically, while gazing at human eyes may be uncomfortable for individuals with ASD, as is commonly reported by those with the condition (Grandin and Panek, 2013), this may not extend to anthropomorphic eyes. For instance, Grandgeorge et al. (2016), compared the gaze patterns of NT children and those with ASD when viewing pictures of human, dog, cat and horse faces. While NT children spent more time looking at eyes in general compared to children with ASD, they spent the most time looking at human eyes. In contrast, children with ASD spent the most time looking at the eyes of dogs and cats and spent the least amount of time looking at human eyes. Saitovitch et al. (2013) also produced similar findings. Children were assessed on their eye gaze patterns when looking at movies with cartoon and human characters. While children with ASD looked significantly less at human eyes compared to controls, they, in contrast, spent an equivalent amount of time looking at cartoon eyes. In this way, it may be that while eye gaze never reaches commensurate levels when compared to NT counterparts, eyes may be more salient when they are anthropomorphic.

These findings may provide support for both the SM and CI aspects of ASD. For instance, with regard to CI, both animals and cartoons may pertain to a restricted interest for the individuals with ASD, which would explain longer looking times toward these stimuli. However, as these studies indicate increased attention toward anthropomorphic eyes, in particular, it may be that this type of stimuli does not result in the same degree of emotional dysregulation when returning the gaze and is thus more motivating (SM).

In summary, it appears that individuals with ASD are more likely to anthropomorphize human-like rather than human faces. The three tenets of anthropomorphism outlined in Epley et al. (2007) may support this claim. For one, a need for sociality may cause individuals with ASD to see the social aspects of anthropomorphic characters in typical ways, and this same desire for sociality is not present to the same extent when stimuli are human. Second, it may be that a motivation to fully understand anthropomorphic creatures has led to typical face processing patterns with regard to these stimuli, particularly in studies demonstrating more typical gaze behaviors toward cartoon and animal eyes. As eyes are the most communicative of mental states, it may be that an increased interest in effectance with anthropomorphic stimuli motivates individuals with ASD to gaze at these types of eyes, while an interest in effectance is weakened when an agent is human. Third, it may be that disruptions of self-representations (Lombardo and Baron-Cohen, 2011), have developed into a greater affinity for human-like rather than human stimuli.

The next section will focus on another foundation of ToM processing, the detection, and recognition of biological motion. There is a significant body of research exploring biological motion recognition in ASD, which has largely concluded that from an early age individuals with the condition are not as sensitive to the movements of human agents. As will be discussed, this sensitivity may be intact relative to controls when individuals with ASD view anthropomorphic biological motion, particularly as development progresses.

## BIOLOGICAL MOTION PROCESSING

While there are several reasons why anthropomorphic faces may be particularly salient to individuals with ASD, research indicates that anthropomorphic motion may also lead to enhanced social processing. An important element of ToM processing involves the recognition and processing of biological motion (Koster-Hale and Saxe, 2013), which contributes to the perception of sentient animacy, such as the smooth movements of a human as opposed to the jerky, artificial movements of a robot (Freitag et al., 2008). For instance, studies using point-light displays have demonstrated that by only showing several animated points meant to represent limbic movement, individuals are sensitive to points that are analogous with the human body (Johansson, 1973).

One reason that biological motion is salient and informative with regard to ToM is that recognizing it enhances a person's ability to make predictions about agent behavior (Koster-Hale and Saxe, 2013). For instance, human movements that violate biological laws, such as a finger bending sideways (Costantini et al., 2005), or a human making robotic movements (Saygin et al., 2012), significantly disrupt a person's ability to predict an agent's future actions. Thus, sensitivity to biological motion is an important mechanism for ToM processing, as it alerts a person not only to agency but bolsters their ability for social action prediction.

Early in development, infants prefer biological motion over artificial or scrambled motion (Simion et al., 2008), and prefer upright over inverted biological motion (Yoon and Johnson, 2009). By the age of two, they are shown to prefer human over non-human biological motion (Chaminade et al., 2015b). As demonstrated by a person's ability to infer emotions (Atkinson et al., 2004), dispositions (Brownlow and Dixon, 1997), and intentions (Runeson and Frykholm, 1983) on the basis of biological motion alone, it is conjectured that recognizing mental states may substantially rely on perceptions of another's motor system honed early in development (Pavlova, 2012).

At a young age children with ASD are shown to be less sensitive to biological motion compared to NTs. For instance, young children with ASD do not differentiate between human and cartoon motion, nor do they prefer artificial or biological motion (Chaminade et al., 2015b). Young children with ASD also struggle to differentiate between biological or scrambled motion when presented in point-light displays (Wang et al., 2015).

Interestingly, research indicates biological motion processing in ASD may be intact later in development when judging non-human biological motion. For instance, Rutherford and Troje (2012), compared adults with ASD to controls on a task using point light displays depicting human, cat and pigeon stimuli. While both groups showed an increased ability to recognize human, then feline, then pigeon motion in a point-light display, there were significant differences between groups in their judgments regarding the direction in which the stimuli were moving. While controls were better able to recognize the direction of human movements, those with ASD were, in fact, better able to determine the spatial direction of the pigeon. This is of particular interest in light of research which indicates that perception of an agent's spatial direction is analogous to their perceived level of animacy; when an individual struggles to orient to the direction of the stimuli, they are equally diminished in their perceptions of its animacy (Chang and Troje, 2008).

Kaiser and Shiffrar (2012), measured adults with varying degrees of ASD traits on their sensitivity to human, dog, and tractor motion. The magnitude of autistic traits negatively correlated with sensitivity to human motion alone. This suggests that deficits attending to and recognizing biological motion may be specifically impaired with regard to human motion; in contrast, the perception of anthropomorphic motion appears intact.

Both SM and CIs patterns in ASD may be responsible for an insensitivity to human biological motion, and a possibly intact sensitivity to anthropomorphic biological motion. For instance, the propensity for NT individuals to "see human," which underscores a sensitivity to human biological motion, may be indicative of increased neural reward activation when processing human movement. Individuals with ASD, who experience hypoactivation in reward systems when interacting with human stimuli (Chaminade et al., 2015a), may, therefore, be less primed to attend to human biological motion. Indeed, research asking participants with different degrees of ASD related traits to assign a value to forms with varying degrees of biological motion found that those with a higher degree of ASD related traits did not assign greater value to human biological motion (Williams and Cross, 2018). This may speak to a decreased motivation to closely attend or engage with purely human stimuli or, equally, an enhanced interest in human-like or anthropomorphic agents.

With regard to the CIs in ASD, it may also be that the motion of animate, non-human creatures, represent motion which is more in line with restricted interests. For instance, individuals with ASD often show restricted interest in objects with mechanical movements (Turner-Brown et al., 2011). This may underlie individuals with ASD's atypical attribution of "humanness" to non-biological, mechanical motion observed in androids (Kumazaki et al., 2017), which in NT's is viewed as less salient and significantly disrupts action perception (Saygin et al., 2012). In this way, individuals with ASD may be both less sensitive to anomalies in human motion as they are less primed to process it preferentially (SM), and the atypicality of non-biological motion, which NTs find unnatural, are of heightened interest to individuals with ASD (CI).

In summary, an important aspect of ToM is the recognition of biological motion, which indicates that the bodily movements of an agent are indicative of human action. Recognizing motion as indicative of human movement allows an individual to better form predictions regarding that agent's intentions and goal-directed behaviors. Beginning at an early age, NT infants are sensitive to human biological motion. Research has found a different developmental trajectory in young children with ASD, who do not show a preference for either biological motion or human agency. This possibly extends throughout adulthood, though some research indicates that by adulthood individuals with ASD are better able to recognize human motion in line with NT adults, though there is some evidence that human biological motion recognition continues to be impaired (Kaiser and Pelphrey, 2012).

Interestingly, two studies indicate that biological motion detection and judgments regarding the direction of biological motion is not impaired in relation to animal motion; individuals with ASD related traits have been shown to be impaired only when attending to human not dog biological motion (Kaiser and Shiffrar, 2012), and those with ASD are best able to predict the direction of pigeon rather than human motion, to an even larger degree than controls (Chang and Troje, 2008). In this way, the processing and recognition of specifically human biological motion may be impaired, while perceptions of anthropomorphic motion may be intact. This may mean that individuals with ASD have developed a sensitivity for non-human motion in line with CI, and are less interested in human biological motion in line with SM.

The finding that biological motion is enhanced when individuals with ASD view anthropomorphic stimuli may also correspond to the Epley et al. (2007) model of anthropomorphism in a similar fashion as findings on anthropomorphic face processing. In particular, an increased ability to anthropomorphize anthropomorphic versus human biological motion may indicate an enhanced social response toward anthropomorphic creatures, in line with the first tenet of sociality. In line with the second tenet of enhanced effectance, if animals represent a restricted interest, individuals with ASD may display a heightened interest in processing anthropomorphic stimuli efficiently, and are thus primed to detect anthropomorphic biological motion. The last of the Epley et al. (2007) tenets, which states that anthropomorphism occurs through eliciting agent knowledge, may be particularly at play in the processing of anthropomorphic biological motion in ASD. For instance, research indicates that the recognition of biological motion is enhanced when an individual is able to map physical aspects of animal motion through the use of a corresponding human reference (Welsh et al., 2014), such as relating the bipedal motion of a walking pigeon to that of a walking human figure. As a physical sensing of the self has been shown to be impaired in those with ASD (Lombardo et al., 2010) it may be that a diminished sense of personal motion may lead to a greater insensitivity to human motion, while not diminishing a sensitivity to anthropomorphic motion. Indeed, if individuals with ASD are more attune to animal rather than human stimuli, as research suggests (Celani, 2002; Prothmann et al., 2009), it may be that elicited agent knowledge in this population takes a more anthropomorphic rather than human form. In the next section, findings relating to increased engagement with anthropomorphic stimuli in individuals with ASD and how this related to ToM is discussed.

## INCREASED ENGAGEMENT WITH ANTHROPOMORPHIC STIMULI AND THEORY OF MIND

It is suggested throughout this review that, be it facial processing or recognition of biological motion, individuals must experience some type interest in a stimulus in order to process it socially. The role of social engagement in anthropomorphism is also central to the Epley et al. (2007) model, in which a desire for sociality is cited as the most important determinant of anthropomorphism. Thus, an underlying argument in this review is that individuals with ASD may find anthropomorphic stimuli more socially motivating than human stimuli, which underlies their enhanced social processing of such stimuli.

Silva et al. (2015) directly tested individuals with ASD on their broader engagement with anthropomorphic stimuli. Adolescents and adults with ASD and age-matched controls were tested on their reaction times when performing the Approach-Avoidance Task (Rinck and Becker, 2007). In this task, the participants' approach or avoidance of either cartoon or human photographed images were measured by the speed in which they manipulated pictures of emotionally positive, negative and neutral social scenes through either the pushing (minimizing image) or pulling (enlarging) of a joystick. Results showed that unlike NTs, those with ASD were significantly more avoidant of emotionally positive photographs, and in contrast found emotionally positive cartoons significantly more approachable. Thus, it may be that the heightened anthropomorphism seen in this population toward anthropomorphic stimuli is reflective of a desire for sociality, a need which may not be met within traditional human encounters.

In a study that more closely examined anthropomorphic engagement and it's effect on ToM, NT and ASD adolescents were tested on their ability to recognize emotional expressions in three types of media (still images, dynamic images, and auditory noise) across human and cartoon stimuli (Brosnan et al., 2015). Results showed that NT adolescents were superior to those with ASD in emotion recognition of human stimuli across all three modalities. This, however, did not extend to animated (cartoon) stimuli. In fact, not only did individuals with ASD significantly improve within group scores on emotion recognition when viewing cartoon versus human stimuli, they outperformed controls in the recognition of static cartoon stimuli. However, it is important to note that accuracy for animated stimuli in the ASD group was never as high as accuracy for human stimuli in the NT group, indicating that cartoon presentation does not entirely compensate for relative ToM-related deficits.

One finding of particular interest related to differences in processing strategies between groups. The researchers found that in the control group, emotion recognition for cartoon and human stimuli were correlated, meaning that the strategies used by controls in one modality were similarly utilized in others. However, no such correlations were found within the ASD group. This indicates that the manner in which individuals with ASD were processing cartoon stimuli was not employed when processing human images, a possible indication that cartoon stimuli were viewed as "special" while human stimuli were not.

The above research suggests that engagement and motivation with regard to anthropomorphic stimuli could ameliorate ToM deficits for those with ASD. One study that tested this was conducted by Golan et al. (2010), and explored whether improving ToM by anthropomorphizing non-human agents could lead to transferable gains in human ToM. In this study, children with ASD aged 4–7 engaged in a 4-week intervention in which they watched instructional ToM videos acted out by toy vehicles grafted with real faces. Following the intervention, the children were assessed in relation to two control groups, one with ASD and one without ASD, both of whom did not partake in the intervention on their ability to generalize learned facial expressions and utilize emotional vocabulary. Results indicated that while the experimental group was indistinguishable from the control ASD group at pre-test, by post-test they had improved to the level of the control group on all four measures. Central to these findings was the children's demonstrated ability to generalize content to not only novel anthropomorphic stimuli but novel human stimuli. This indicates that the intrinsic interest individuals with ASD showed toward areas of restricted interest may have promoted their interest and understanding in human stimuli.

In relation to the Epley et al. (2007) model, anthropomorphic stimuli may enhance sociality, increase the desire for effectance, and is not viewed as incongruent with the physical self. The following section will focus on the second tenet of the model, in which it is found that a desire for efficacy promotes anthropomorphism. Studies documenting an increased desire for efficacy in individuals with ASD when processing anthropomorphic characters due to stylization/exaggeration, and extensive previous experiences with such stimuli, will be explored.

## EFFECTANCE WITH STYLIZATION/EXAGGERATION

As previously discussed, research indicates that individuals anthropomorphize in order to increase their efficacy in understanding a non-human entity and this is enhanced when behavior is less predictable (Waytz et al., 2010b). One aspect of anthropomorphic stimuli that may particularly increase effectance of individuals with ASD is the stylization and exaggeration of social features in such agents, which may highlight a sense of unpredictability regarding their intentions. Support for this comes from research showing that within this population the recognition of changes in emotion may be impaired, while the perception of changes in motion is intact (Han et al., 2015). This may mean that the exaggerated movements used by anthropomorphic characters to express emotions may be more noticeable to those with the condition, while changes in emotion may be missed and thus not utilized when making judgments of unpredictability.

Research on animal movement, for instance, indicates that individuals largely rely on physical movements, such as the motion of the tail and muzzle cues like the baring teeth, when identifying an animal's mental state (Tami and Gallagher, 2009). Thus individuals with ASD may be better equipped to attend to animal emotion, as it involves the interpretation of overt movement rather than subtle changes in facial expression. In this way, the unpredictability of animal agents may be more noticeable, thus leading to a greater desire for effectance. Cartoon characters are also characterized by exaggerated motion (Thomas et al., 1995), which serves to direct attention toward socially relevant aspects of the animation (Gielniak and Thomaz, 2012). In a similar way to animal agents, individuals with ASD may be more primed to attend to the unpredictability of cartoon motion as it is exaggerated and thus more salient.

Carter et al. (2016) provides preliminary support for the hypothesis that exaggerated motion in anthropomorphic stimuli increases interest in effectance. In this study, children with ASD interacted with animated avatars with varying degrees of facial emotional exaggeration. When an avatar showed exaggerated facial motion, compared to dampened or realistic motion, nonverbal behaviors such as gaze or gesturing significantly increased. This is in line with research showing that individuals with ASD are less impaired when interpreting overt emotional expressions, and struggle more with the detection of subtle facial emotional changes (Rump et al., 2009). Anthropomorphic faces, which exaggeration makes more emotionally intense (Hyde et al., 2014), may heighten their unpredictability and lead to a greater desire for effectance, while subtle changes in realistic human agents are less salient, and result in a decreased desire for effectance.

## EFFECTANCE FROM CARTOON AND ANIMAL EXPERIENCE

### Cartoon Experience

An important aspect of the desire for effectance brought up in Epley et al. (2007) is people anthropomorphize out of a desire for 'closure' or understanding of an agent. One reason that individuals with ASD may anthropomorphize cartoon stimuli more than human stimuli is that familiarity with such content has led to an increased sense of self-efficacy in understanding such stimuli. Heightened interest and time spent attending to animated stimuli is well documented in this population. For instance, survey data shows that adolescents with ASD spend a significant amount of time engaging with electronic screen media (Mazurek et al., 2012). Surveys given to parents of children with ASD indicate that electronic screen engagement is their most common leisure activity, in particular animated television shows and movies (Shane and Albert, 2008). Kuo et al. (2014) also found that within a sample of adolescents with ASD, cartoon television programs were the most popular television genre, and 66% of the sample reported a preference for animation over any other type of media.

Drawing a causal relation between cartoon viewing and increased ToM abilities with regard to cartoon stimuli remains ambiguous. As has been discussed previously in this review, there are reasons why the stylized exaggeration inherent to animated media may attract individuals with ASD to this medium. For one, the exaggerated and amplified motion may allow for greater success when making ToM judgments, leading to enhanced self-efficacy and thus greater enjoyment of this type of media. As individuals with ASD report increased familiarity and exposure to this form of media, it may be that they have an increased expertise in processing cartoon stimuli, which has led to the type of FFA activation that enhances ToM related processing. This may increase a desire for effectance in relation to cartoons, as individuals with ASD may feel better equipped to understand the meaning behind the social acts depicted in cartoon form due to their increased exposure, thus increasing their tendency to anthropomorphize (Epley et al., 2007).

## Animal Experience

Individuals with ASD also show increased motivation and experience regarding animal stimuli. For instance, Celani (2002) compared children with ASD to NTs, and those with intellectual disabilities, on their preferences for human, animal and object stimuli. While children with ASD significantly preferred objects over human stimuli, they showed a significantly greater preference for animals than all other types of stimuli. Prothmann et al. (2009) showed children with ASD interacted significantly more frequently and for a longer duration with a dog than a person or toy, when through a free-choice paradigm. Both provide evidence of an implicit preference in individuals with ASD for animal stimuli, which may motivate attention to animals over humans.

With regard to animal experience, it is estimated that 1 in 4 children with ASD have participated in animal therapy at some point, and two-thirds of parents report improvements following animal-assisted interventions (Christon et al., 2010). Research also indicates that families of children with ASD may have a particularly high rate of pet ownership, as 81% of families with a child with ASD surveyed on pet ownership reported owning pets (Carlisle, 2014), while the national average is around 66% according to the American Veterinary Medical Association [AVMA] (2012). Further findings in this study indicated that 94% of children with ASD were described by parents as having bonded with their pets, with common bonding activities including talking and actively playing and petting their pets. Parents commonly reported that they believed pets provided specific benefits to their children with regard to alleviating common challenges related to ASD, and 26% of parents reported that the perceived benefits of animal contact on ASD symptoms factored into their decision to own a pet, particularly dogs. Surveys of individuals with ASD also indicates strong perceived attachments between themselves and their pets (Carlisle, 2015).

Together, these results indicate that not only do individuals with ASD commonly have extensive contact with animals but that these encounters are viewed quite positively by both themselves and close others. Given that individuals with ASD often report a significantly high degree of negative social experiences (White et al., 2011; Lamport and Turner, 2014), and decreased social self-efficacy (Vickerstaff et al., 2007), successful encounters with animals may increase a desire for effectance, as previous positive encounters with animals may have incentivized understanding animal agents (Epley et al., 2007).

Considering this evidence, it appears that individuals with ASD on average tend to have frequent and positive experiences interacting with animals and cartoons, either through media engagement, structured animal-assisted interventions, pet-ownership, or all three. In this way, the positive social experiences individuals with ASD have had with regard to anthropomorphic agents may lead to greater motivation to interact effectively with such stimuli. As individuals with ASD have experienced social reward associated in particular with animal engagement, anthropomorphizing animals may happen out of a desire to further understand and predict the behavior of this stimuli. Additionally, a heightened exposure to cartoons may lead individuals with ASD to view understanding the mental states of cartoons as within their control. In contrast, it may be that individuals with ASD view the processing of human stimuli as less in their control, and they show decreased anthropomorphism for human agents.

# SUMMARY

The processing of mental states is a complex, multi-faceted procedure that requires lower-level inputs in order to produce higher-order ToM explanations. Individuals with ASD have been shown to struggle with ToM throughout development, and evidence suggests that lower-level processing impairments such as reduced facial and biological motion processing may play a significant role in this disruption. In particular, it appears that individuals with ASD have early insensitivities to human agency, namely attending to human faces and human biological motion.

While evidence suggests that individuals with ASD show significant deficits in relation to recognizing and processing human stimuli, they are conversely shown to display a heightened interest in non-social stimuli compared to NTs. The SM and CI aspects of ASD complement one another in their explanations of these deficits. In relation to SM, early deficits in relation to human social processing, which primes NTs to preferentially attend to such stimuli through an associated neural reward system, is impaired in those with ASD. This may lead to decreased reward circuitry, and thus less holistic and preferential processing of human stimuli, which impairs ToM processing at lower levels of input. Additionally, the preference individuals with ASD show toward non-social stimuli (CI), particularly objects in the environment that have ordered motion or systems, may reflect a preference to attend to items of restricted interests in place of social stimuli. In this way, the increased motivation to attend to non-social stimuli may impact the motivation to attend to less-ordered, more complex social stimuli.

However, the many studies detailed in this review indicate that engagement with anthropomorphic stimuli may function as a bridge for individuals with ASD to attend to social stimuli. In line with SM, it is hypothesized that the developed stressors associated with human contact may not extend to human-like stimuli. In this way, individuals with ASD may be more motivated to attend to anthropomorphic stimuli in typical ways, as anthropomorphic stimuli feature properties that differentiate them from purely human agents. It is also hypothesized that as individuals with ASD are able to attend to motion, and struggle with the nuances of emotion, an ability to decode animal and cartoon emotion using overt movement cues could make social processing less difficult, thereby enhancing SM. The frequent exposure to cartoons and animal agents may also serve to enhance motivational engagement with such stimuli.

Also playing an important role in anthropomorphic social processing is found in aspects of CIs in those with ASD. Properties of anthropomorphic agents that correspond to restricted interests, including stylized physical properties and an association with an exaggerated motion, may direct attention to these agents over and above agents that are purely human. For instance, individuals with ASD report an enhanced interest and experience with cartoon stimuli, and the overt, exaggerated aspects of cartoon motion may be particularly salient. In this way, anthropomorphic agents may represent an area of expertise for individuals with ASD, therefore enhancing their ability to attend to them holistically.

For these reasons, it is suggested that while the social processing of human stimuli appears to be impaired in this population, the processing of anthropomorphic stimuli is either less pronounced, intact or even enhanced. Thus, using anthropomorphic stimuli to develop social processing in individuals with ASD may help ameliorate a decreased motivation to engage with human stimuli. It may also aid individuals with ASD in the processing of social over non-social stimuli, as anthropomorphic creatures are social agents, yet they also possess physical characteristics reminiscent of restricted, non-social interests. The implications of these findings are discussed below.

## IMPLICATIONS

There are several important implications for the increased social processing of anthropomorphic stimuli in individuals with ASD. Chief among them is the possibility that increasing social cognitive development in relation to anthropomorphic stimuli may serve as a scaffold for transferring these skills to human stimuli. There is some evidence that supports this claim. For instance, Golan et al. (2010) showed that improvements understanding mental state language in connection to anthropomorphic characters transferred to social gains with human stimuli. This indicates that the use of areas of CI when combined with human elements may help improve ToM when interacting with non-CI related agents.

Research on animal-assisted interventions such as equine therapy indicates that skills learned with animal agents transferred to real life social improvements even when measured 1-month post-trial (Gabriels et al., 2015). Studies measuring naturalistic social improvements also show that in the presence of animals, real-life social functioning can improve, and importantly lead to greater peer acceptance (O'Haire et al., 2013). These studies indicate that the enhanced social processing, and the motivation experienced by individuals in relation to anthropomorphic stimuli, may transfer to improvements in human interactions.

Perhaps most significant is the possibility that perceived self-efficacy with anthropomorphic stimuli can lead to gains in perceived self-efficacy in relation to humans, and human encounters. Underlying the "eye avoidance" hypothesis of ASD (Tanaka and Sung, 2016) is that individuals with ASD develop gaze aversion in relation to human contact, as they may implicitly equate eye gaze with social demands that they cannot meet. For instance, evidence shows that in preschool there is not the same aversion to mutual gaze and emotional dysregulation in children with ASD (Nuske et al., 2015), and 2-year-old children with ASD show eye indifference rather than eye avoidance, as they can be primed to view eyes (Moriuchi et al., 2016).

However, research also indicates that in adults with ASD there is a distinct aversion to direct eye-gaze (Kliemann et al., 2012), and that direct eye gaze results in hyperactivation in subcortical areas of the brain, indicating dysregulation (Hadjikhani et al., 2017). This may indicate that early eye indifference later results in eye avoidance, leading to a possibility that commensurate with age, individuals with ASD may develop a human-specific social aversion. In contrast, early eye insensitivity may not impact individuals with ASD's perceived self-efficacy with anthropomorphic agents. In this way, the negative associations that may impede further development of social processing in relation to human stimuli may not interfere with development in regard to anthropomorphic social processing. This reflects theories of ASD relating to social compensation (Livingston and Happé, 2017), and it may be that the difficulties associated with human agents are compensated for when interacting with non-human agents.

With regard to compensation, it may be that an ability to process anthropomorphic social cues creates a pathway to developing social processing competencies, and this may be a bridge to developing competencies with human stimuli. For instance, research indicates that the same brain regions are recruited when individuals use ToM in relation to animals as they do in relation to humans (Desmet et al., 2017), and those facial expressions in both animals and humans are processed similarly (Schirmer et al., 2013). Interestingly, research indicates that when assessing the emotions of dogs, individuals often used their own emotions as a template (Konok et al., 2015). In this way, engagement with mentalizing about animals may lead to increased processing of personal emotions, which has been shown to be impaired in individuals with ASD (Jackson et al., 2012), and thus may be an important mechanism for ToM improvement (Allan et al., 2017). Effective reasoning about anthropomorphic social agents may, therefore, transfer to efficacy with human agents and even efficacy in understanding the self.

There are several implications for interventions with regard to enhanced social processing for anthropomorphism. One is that, in line with Golan et al. (2010), it may be advantageous to use anthropomorphic stimuli when engaging individuals with ASD in ToM interventions. In particular, future interventions of this nature should focus on scaffolding, and slowly applying strategies toward more human-like stimuli presentations.

It is also of interest to examine how longitudinal interventions with anthropomorphic stimuli may differentially affect what may be a developed aversion to human stimuli in older individuals with ASD.

In particular, O'Haire et al. (2013) indicates that interactions with animals by both children with ASD and NTs in a classroom setting enhances social reciprocity. It may be that structuring inclusive classroom settings to involve animal contact may improve social outcomes for individuals with ASD and foster greater peer acceptance. This may help counteract some of the negative social experiences often reported by individuals with ASD, and lead to greater self-efficacy in relation to social encounters. Experiential accounts from individuals with ASD often report attachment and elevated self-esteem in relation to anthropomorphic agents, particularly animals. It may be that anthropomorphism for this population allows those with ASD to experience social engagement in a way that feels more natural, and thus can aid in transferable ToM gains to other social settings.

In closing, the Epley et al. (2007) model of anthropomorphism uses three tenets to explain why people anthropomorphize. It is suggested that individuals with ASD may use anthropomorphic creatures as a social outlet of sorts, and in this way, a desire to see the social aspects of anthropomorphic creatures leads to better holistic processing of this stimuli. Individuals with ASD may also have a greater desire to understand anthropomorphic creatures, as they have had success understanding and interacting with such agents, and the agents have properties related to CIs, which enhances a desire for effectance. Additionally, a decreased salience for humans and an increased salience for anthropomorphic characters, perhaps tied to exaggerated motion and a poor detection of emotion, may lead to a stronger recognition of unpredictability, thus enhancing a desire for effectance with anthropomorphic creatures. Finally, individuals with ASD have a diminished physical sense of self and are less sensitive to anomalies in the human form. While this impedes anthropomorphizing non-human creatures in those who are NT, this may not lead to the same types of processing deficits in individuals with ASD. Conversely, the aspects of the physical self that, in individuals with ASD, are less salient or noticeable, may lead to a heightened identification with other "more than human" and thus more exaggerated stimuli.

At present, investigations into anthropomorphism have found that ToM impairments correspond to impairments anthropomorphizing (Cullen et al., 2014). It may be of interest to examine whether this is unilaterally the case with individuals with ASD. For instance, research shows that in anthropomorphic assessments using animated shapes, individuals with ASD are less able to anthropomorphize (Abell et al., 2000). However, it may be that with more socially enriched stimuli, such as animal or human cartoon stimuli, individuals with ASD may display a different pattern with regard to anthropomorphism and ToM. Additionally, as is explored by Brosnan et al. (2015), deficits relating to ToM may be ameliorated when stimuli take a less human form. It would be of particular interest to test whether this can be replicated, particularly through the use of non-visual ToM paradigms, in order to assess the purely cognitive aspects of mental state representations and their connection with anthropomorphism in this population. It would also be of interest to further understand how anthropomorphism and self-perceptions interact in ASD, and whether anthropomorphism can serve as a pathway for improving intrapersonal as well as interpersonal social processing, and ToM more generally.

In conclusion we have highlighted how the ability to anthropomorphize may not only be intact in those with ASD, but those with the condition may even display a particular affinity for seeing human in the non-human. Evidence suggests that ToM abilities, which are usually disrupted in this population, may be ameliorated, spared, or even enhanced when they are directed toward anthropomorphic rather than human agents. As we have shown, anthropomorphizing may be a potential scaffold for improving ToM abilities more generally in this population, as they correspond with a number of strengths intrinsic to ASD. Identifying and capitalizing on such strengths may be the key to improving ToM, and allowing those with ASD better integration within the wider social world.

*I moved full circle form being a wild thing out of context as a child, to being a wild thing in context with a family of gorillas, who taught me how to be civilized. They taught me the beauty of being wild and gentle together as one (Prince-Hughes, 2004, p. 1).*

## AUTHOR CONTRIBUTIONS

GA and LC contributed to the design, structure, content of the review, and writing the final draft. GA prepared the first draft.

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# The Biology and Evolution of the Three Psychological Tendencies to Anthropomorphize Biology and Evolution

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At the core of anthropomorphism lies a false positive cognitive bias to over-attribute the pattern of the human body and/or mind. Anthropomorphism is independently discussed in various disciplines, is presumed to have deep biological roots, but its cognitive bases are rarely explored in an integrative way. Conversely, I present an inclusive, multifaceted interdisciplinary approach to refine the psychological bases of mental anthropomorphism. I have integrated 13 conceptual dissections of folk finalistic reasoning into four psychological inference systems (physical, design, basic-goal, and belief stances); the latter three are truly teleological and thus prone to anthropomorphisms. I then have integrated the genetic, neural, cognitive, psychiatric, developmental, comparative and evolutionary/adaptive empirical evidence that converges to support the nature of the distinct stances. The over-reactive calibration of the three teleological systems prone to anthropomorphisms is framed as an evolved design feature to avoid harmful ancestral contexts. Nowadays, these stances easily engage with scientific reasoning about bio-evolutionary matters with both negative and positive consequences. Design, basic-goal, and belief stances benefit biology by providing cognitive foundations, expressing a high-powered explanatory system, promoting functional generalization, fostering new research questions and discoveries, enabling metaphorical/analogical thinking and explaining didactically with brevity. Hence, it is neither feasible nor advantageous to completely eliminate teleology from biology. Instead, we should engage with the eight classes of problems in bio-philosophy and bio-education that relate to the three stances: types of anthropomorphism, variety of misunderstandings, misleading appeal, legitimacy controversy, gateway to mysticism, total prohibition and its backfire effect. Recognizing the distinction among design, basic-goal, and belief stances helps to elucidate much of the logic underlying these issues, so that it enables a much more detailed taxonomy of anthropomorphisms, and organizes the various misunderstandings about evolution by natural selection. It also offers a solid psychological grounding for anchoring definitions and terminology. This tripartite framework also shed some light on how to better deal with the over-reactive stances in bio-education, by organizing previous pedagogical strategies and by suggesting new possibilities to be tested. Therefore, this framework constitutes a promising approach to advance the debate regarding the psychological underpinnings of anthropomorphisms and to further support regulating and clarifying teleology and anthropomorphism in biology.

**Keywords: anthropomorphism, teleology, mentalizing, intentional stance, theory of mind, natural selection, education, misunderstandings**

# INTRODUCTION

The search for pertinent pattern is the world is ubiquitous among animals, is one of the main brain tasks and is crucial for survival and reproduction. However, it leads to the occurrence of false positives, known as patternicity: the general tendency to find meaningful/familiar patterns in meaningless noise or suggestive cluster (Shermer, 2008). Patternicity can be visual, auditory, tactile, olfactory, gustatory or purely psychological. It varies from enabling normal analogical reasoning, in which the process of schema transfer from a familiar domain is intentionally used to clarify a problem in another domain (Wong, 1993), to pathological cases of hallucinations (Waters and Fernyhough, 2017). Patternicity is an umbrella term encompassing different kinds of over-attribution (**Figure 1**). Among related phenomena there is *anthropomorphism*: finding the pattern of human body and/or intentional mind where there is only vague similarity, suggestive resemblance, noise or nothing.

Is anthropomorphism just a mistake or a potent adapted bias? Is it something we should suppress or exercise with precision? This review is focused on integrating the biological foundations and psychological scope underpinning the tendency toward anthropomorphism, particularly the over-interpret of mentality where there is none. I firstly present its widespread status throughout several disciplines and highlight that the authors often presume a deep biological root for the tendency toward mental anthropomorphism. Do we really have an evolved built-in propensity to anthropomorphize? If so, how many psychological systems are engaged along the process? I then organize several conceptual dissections converging toward a tripartite division of the main cognitive faculties leading to mental anthropomorphism. Afterward, I present a cross-disciplinary summary of evidence offering a biological foundation of the three distinct mental capacities, pointing to adaptive values.

In the second half of this review, I show that the same psychological capacities prone to anthropomorphize are activated within biological sciences. Do they hinder or aid to advance the biological reasoning? After presenting its positive consequences, I show how the comprehensive and tripartite view of the psychological scope underlying mental anthropomorphism can illuminate their negative consequences to biology, such as organizing the misunderstandings about natural selection. Should we avoid the mistaken explanations or come up with ways to used them in favor of a more intuitive and accurate understanding? At the end, I present some pedagogical strategies known to be effective for teaching evolution and new ones to be tested based on this framework. I hope to advance the philosophical and educational debate concerning mental anthropomorphism by providing interdisciplinary evidence about the foundation and tripartite nature of the cognitive tendencies prone to anthropomorphize biology and natural selection. The same way humans were able to tame the destructive nature of fire to get light, heat, cooked food, locomotion, up to fire juggling, it seems feasible and productive to train the anthropomorphic tendencies for the best once uncovering its inner properties.

## The Widespread Status of Anthropomorphism

Anthropomorphism is widespread in both of its branches. Human pareidolia occurs when we see humanoid figures/faces in clouds, landscapes, rocks, or other objects (Guthrie, 1993). Neuroscientific evidence shows that women are more prone than men to see faces where there are none (Proverbio and Galli, 2016). The tendency for perceiving and preferring faces in face-like stimuli is present in newborn human infants (Johnson et al., 1991; Simion et al., 2001) and in juvenile monkeys raised without exposure to real faces (Sugita, 2008). Thus, familiarity and deep phylogenetically inherited knowledge about how humans (primates) look and behave play a role (Eibl-Eibesfeldt, 1989).

Anthropomorphic pareidolia lies in the evolutionary roots of human representational artistic propensity (Morriss-Kay, 2010; Varella et al., 2011b; Bednarik, 2016). Varella et al. (2011a,b, 2012) defended an evolutionary trajectory of paleoart aesthetics that started with a preexisting propensity to perceive/prefer patterns of anthropomorphs, zoomorphs, social scenarios and skillfulness that were later co-opted to recognize/appreciate paleoart visual content. Later this cooptation was expanded particularly through sexual selection into artistic instincts. Indeed, the earliest paleoaesthetics evidence points to the capacity of pre-sapiens, possibly *Homo heidelbergensis,* to detect anthropomorphic properties of objects and to improve it, such as in the case of the proto-figurine from Tan-Tan (300k - 500k BP) and Berekhat Ram (250k - 280k BP) (Bednarik, 2003; Morriss-Kay, 2010). The oldest case of face pareidolia dates from 3 million years ago, before the genus Homo. A 5cm dark red jasperite pebble, known as Makapansgat cobble, has natural makings in the appearance of a face and was found in a cave of Australopithecine. There is no intentional modification to the pebble which originated at least 32 km away from the cave. Thus, it was carried to the cave, possibly because of the hominid's capacity toward anthropomorphic facial pareidolia being activated by the suggestive form of the pebble (Bednarik, 1998; Morriss-Kay,

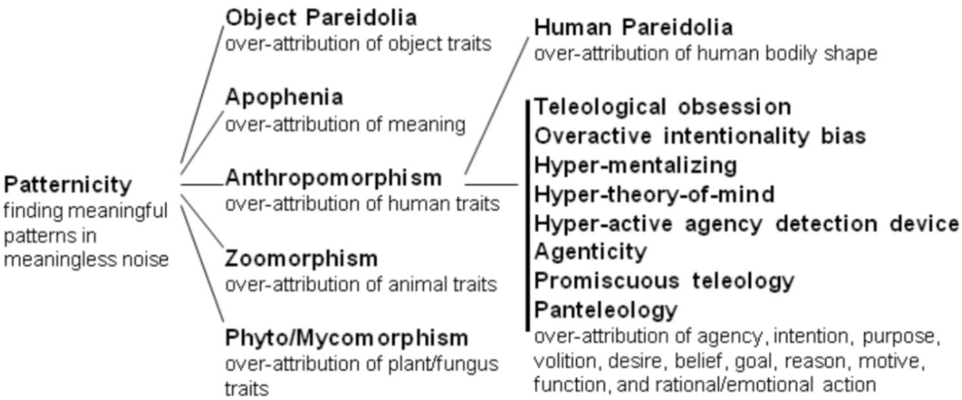


**FIGURE 1** | Possible organization of the conceptual relationship among the many types of over-attribution tendencies within patternicity. In general, those tendencies occur respectively when we see specific objects, meanings, human forms/minds, non-human animal forms/minds, plant forms, or fungus forms where there is only vague similarity or none.

2010). Similarly, today the *Chinsekikan* Museum (The Hall of Curious Rocks) in Japan houses over 1,700 rocks that naturally resemble human faces, including Elvis Presley (Nace, 2016).

Conversely, the mental branch of anthropomorphism is fascinating given its psychological nature. It is the false positive bias of over-attributing agency, intention, purpose, volition, desire, belief, goal, reason, motive, function, and rational/emotional action where there is only vague suggestive similarity or none. A 'rock' example comes from the 'sailing' stones from Death Valley (California). These stones leave behind long parallel, almost linear, track marks that are suggestive of self-propelled movement and rational choice for the shortest route toward an targeted place. Actually, Norris et al. (2014) discovered that melting thin ice sheets underneath the stones and light winds generate the apparently purposeful movement.

Many authors reserve the use of the term anthropomorphism only for its mental branch (e.g., Fisher, 1996; Reiss, 2017). The concept is so widely relevant that authors from various perspectives independently call it different names (**Figure 1**). Bacon (1878) referred to "**idols of the tribe**" when he stressed that human nature is such that it sees final causes (goals, reasons) everywhere even though they belong 'only' to human nature and not to the nature of the universe *per se*. Richard Dawkins referred to it as "**purpose colored spectacles**" during his BBC special "The big question: Why are we here?" in 2006[1]. Within cognitive ethology, it is called "**Intuitive anthropomorphic bias**" (e.g., Dacey, 2017), and it helps to clarify how to better interpret non-human behavior. In the intersection between cognitive science and robotics, it is called "**Anthropomorphic projection**" (e.g., Airenti, 2015), where it helps to explore possible meaningful interactions between people and artificial intelligence agents. Within cognitive psychology, it is called "**Teleological obsession**" (e.g., Csibra and Gergely, 2007) or "**Overactive intentionality bias**" (e.g., Rosset, 2008), where it helps to better understand why people pervasively presume intentional action in all behaviors. Within psychiatry, it is known as "**Hyper-mentalizing**" (e.g., Badcock, 2004) or "**Hyper-theory-of-mind**" (e.g., Clemmensen et al., 2014), where it helps understanding episodes of paranoia, persecutory thinking and related delusions in schizophrenic patients. Evolutionary theories of religiosity call it "**Hyper-active agency detection**" (e.g., Guthrie, 1993; Barrett, 2000; Boyer, 2001), where it helps to understand animism and the origins of the widespread belief in supernatural beings/deities. Within critical thinking and skepticism, it is known as "**Agenticity**" (e.g., Shermer, 2011), where it helps understanding the prevalent interest in conspiracies, paranormal events and supernatural/intelligent beings, such as ghosts and aliens. Within bioscience education, it is known as "**Promiscuous teleology**" (e.g., Kelemen, 2012), where it helps understanding why students often have a "function compulsion" of attributing intentionally designed use to everything. Finally, within bio-philosophy it is known as "**Panteleology**" (e.g., Mahner and Bunge, 1997), where it helps to distinguish theoretical conceptions attributing finality to all things in the cosmos, from those that attribute it only to some things (Hemiteleology). Importantly, those terms are not exact synonyms because they vary in the extension of the meaning. "**Teleological obsession**" and "**Overactive intentionality bias**" have the narrowest meaning, because they refer to anthropomorphizing of 'only' all human behavior (even involuntary ones), while "**Promiscuous teleology**" and "**Panteleology**" have the broadest meaning, because they refer to anthropomorphizing of everything in the cosmos.

## Mental Anthropomorphism as Built-In Default Bias

As outlined, the existence and importance of mental anthropomorphism is convergent and recognized across life domains. A crucial step for achieving this level of interest is the recognition that anthropomorphism is more than just a jargon or category mistake (Fisher, 1996). Rather, it is a result of a specific underlying cognitive bias that is somehow overly active

[1]Richard Dawkins at the 20 min 12 s of "The Big Question: Why Are We Here?" https://www.youtube.com/watch?v=sWaLBiM6O5k

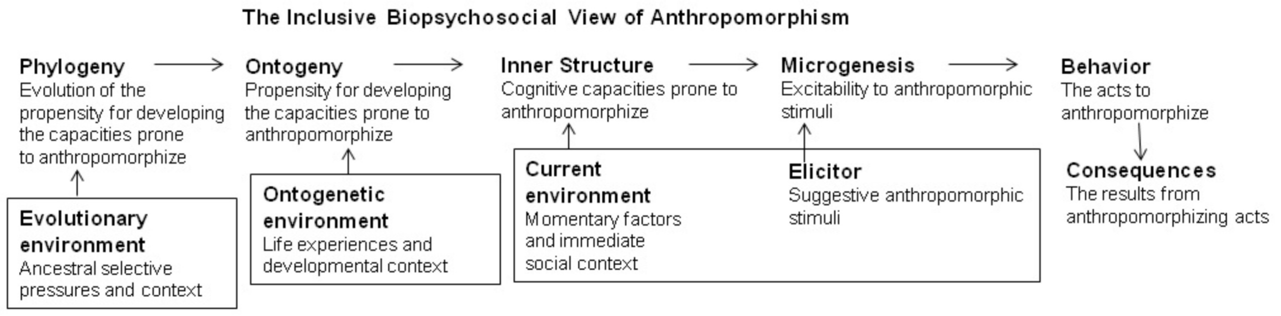


**FIGURE 2 |** Inclusive bio-psychosocial integration of the factors related to anthropomorphizing in different time scales under different environmental influences; inspired by the way ethologists distinguish among behavior, its elicitor, its capacities, development and evolution (cf., Hinde, 1982; Hogan, 2017).

(e.g., Broaddus, unpublished; Shermer, 2011; Airenti, 2015; Engvild, 2015; Dacey, 2017). Reiss (2017) argued that the notion that anthropomorphism is only a source of error that needs to be reconsidered. Fisher (1996) affirmed that the charge of anthropomorphism oversimplifies a complex issue. Dacey (2017) stated that anthropomorphism-as-an-error underestimates its complexity and that in order to better understand and control it, we must treat it as a cognitive bias. Following in the steps of Piaget, Chomsky, Tversky, and Kahneman, the idea is to take seriously the mistake: as a window to explore and uncover new facets of the human mind. This shift of focus can build a common base to further explore and to integrate the phenomenon.

Further, there is general agreement that mental anthropomorphism is a "strong and early inclination" (Csibra and Gergely, 2007, p. 60), a "powerful bias" that "runs very deep," "the default mode" (Gregory, 2009, p. 167), a "deep-seated tendency" (Rose and Schaffer, 2017, p. 243), that "feels natural" and "automatic," an "innate disposition," a "hard-wired tendency" (Broaddus, unpublished, p. 2, 4, 11), it is "simply built into us" (Kennedy, 1992, p. 28), "involuntary" and "pervading human thought and action" (Guthrie, 1993, p. vii–viii), and "at least as old as humankind" (Mahner and Bunge, 1997, p. 367). These descriptors convey the notion that mental anthropomorphism has impressive biopsychological roots. To further evaluate these assertions, it is important to distinguish among the objects triggering anthropomorphism, the anthropomorphic act, the capacities and its readiness, the propensity to develop the capacities and its evolution (**Figure 2**). Additionally, when focusing on "innate," "natural," and "hard-wired" one easily may forget about the importance of learning and of environment (cf., Dar-Nimrod and Heine, 2011; Heine, 2017). Thus, in **Figure 2**, I integrate the biopsychosocial influences in each time scale.

## AIMS

Given its widespread status, growing convergent interest, and the presumed bio-psychological roots of mental anthropomorphism, I aim to dissect and to integrate the main points about the biology, cognition, development and evolution of psychological tendencies to over-attribute mentality, in order to build a comprehensive view. I then use this inclusive view to illuminate cases and issues of anthropomorphism in biology and evolution, as well as to help promote more effective strategies to deal with its positive and negative sides. This approach is aligned with evolutionary educational psychology (Geary, 2002) and with other attempts aimed at integrating different perspectives about mental anthropomorphism and its implications for understanding life (e.g., Whiten, 1991; Broaddus, unpublished; Galli and Meinardi, 2011; Shermer, 2011; Airenti, 2015; Engvild, 2015; Dacey, 2017; Dink and Rips, 2017). The main difference is that I propose a tripartite approach for the psychological scope of mental anthropomorphism.

## THE PLURALITY OF TELEOLOGICAL REASONING UNDERLYING MENTAL ANTHROPOMORPHISM

The more we discover about anthropomorphism, the more the usual unitary view becomes an impediment. A pluralist approach puts things in perspective, contextualizes the problem, integrates disparate ideas, and fosters new hypotheses and conclusions. An important step toward a refined multifaceted view about mental anthropomorphism is to avoid an essentialist bias. Psychological essentialism is another highly accessible intuitive mode of thought that has five related components: stability, boundary intensification, within-category homogeneity, causes inherent in individuals, and existence of ideal categories (Gelman and Rhodes, 2012). Thus, in order to counteract the essentialist intrusive tendency, it is vital to think about teleological reasoning and its over-extended case in gradual terms, stressing flexibility, overlaps, heterogeneity and diversity, internal and external causes, imperfections, as well as considering the existence of versions in other animals (cf., Heine, 2017).

Although the overall mode of reasoning that configures mental anthropomorphism is commonly framed as teleological reasoning, i.e., thinking that generates a style of explanation dealing with goals, purposes, and reasons (e.g., Mahner and Bunge, 1997; Broaddus, unpublished; Engvild, 2015), it does not follow necessarily that its underlying biological, cognitive and

**TABLE 1 |** Integration of 13 plural conceptualizations of the teleological reasoning according to which phenomena it is thought most suitable to apply.

| **Natural effects** | **Advantageous specialized use** | **Optimized self-interested patterned actions** | **Optimized self-interested reasoned inventive tactics** | **Intuitive focus** |
|---|---|---|---|---|
| Inorganic/physical phenomena | Tools, body parts, social role | Prey, predators | Human conspecifics | Phenomena directed |
| *Endpoint- Attaining Systems*<br>• No design/proper function<br>• No agent goal<br>• Nor belief | *Designed Goal-Achieving Systems*<br>• Artificial or natural design/proper function<br>• No agent goal<br>• Nor belief | *Designed Goal-Pursuing Agent*<br>• Natural or artificial design/proper function<br>• Agent goal<br>• No false belief | *Designed Goal-Intended Believing Agent*<br>• Natural or artificial design/proper function<br>• Agent goal<br>• False belief | Phenomena specified<br><br>Authors |
| – | Functional ascription | Goal-ascription | Intention-ascription | Beckner, 1969 |
| Teleomatic language | Teleonomic language | Teleological language | | Mayr, 1974, 2004 |
| Physical stance | Design stance | Intentional stance | | Dennett, 1989 |
| – | – | Desire psychology | Belief-desire psychology | Wellman, 1991 |
| Causal formulation | Non-anthropomorphic teleological reasoning | | Anthropomorphic teleological reasoning | Tamir and Zohar, 1991 |
| Physical mechanics mode of construal | Functional/teleological mode of construal | Folk psychology mode of construal | | Keil, 1994 |
| – | Teleonaturalism | | Teleomentalism | Allen and Bekoff, 1995 |
| – | – | Behavior-reading ability | Mind-reading ability | Whiten, 1996 |
| Intuitive physics system | Structure-function system | Goal-detection system | Intuitive psychology system | Boyer, 2001 |
| – | Functional stance | Teleological representation | Mentalistic representation | Gergely and Csibra, 2003/Csibra and Gergely, 2007 |
| Mechanism, mode of cognition | | Mentalism, mode of cognition | | Badcock, 2004 |
| Systemizing system | | Intentionality detector | Theory of mind mechanism | Baron-Cohen, 2005 |
| – | – | Low-level mindreading | High-level mindreading | Apperly, 2011 |

evolutionary processes must be unitary. However, teleological reasoning "rests on poorly understood psychological primitives" (Schoemaker, 1991, p. 205), and many authors tend to assume its cognitive base stems only from folk psychology (e.g., Godfrey-Smith, 2009). A plural conceptualization of folk teleological tendencies toward mental anthropomorphism is found in philosophy (e.g., Dennett, 1989, 2017; Mahner and Bunge, 1997; Mayr, 2004); psychology (e.g., Rosset, 2008; Apperly and Butterfill, 2009; Schaafsma et al., 2015); development (e.g., Gergely and Csibra, 2003); and neuroscience (e.g., Saxe et al., 2004).

Therefore, in order to set the stage for integrating the factors related to mental anthropomorphism, **Table 1** organizes 13 ways in which underlying teleological cognition has been conceptually dissected into sub-domains by different authors with philosophical or psychological backgrounds. These sub-domains of teleological reasoning are referred to as specialized cognitive mechanisms or its products: ascriptions, stances, psychologies, representations, inference systems, languages, or modes of thought. Despite some inconsistencies usually stemming from different frameworks of authors, the clear pattern is the convergent and consistent division of teleological reasoning into specific sub-domains (**Table 1**). Most authors devise two or three sub-domains, but by analyzing all approaches together, a four sub-domain solution seems to be all-encompassing and stronger (cf., Boyer, 2001).

In general, the sub-domains are specialized to track different relevant phenomena, as two kinds of systems and two kinds of agents (**Table 1**). The **physical** stance tracks the natural inorganic systems without signs of design nor inorganic beneficiaries of possible effects. The **function/design** stance tracks naturally or artificially designed systems (i.e., parts of living beings, tools) presenting proper functions and having individuals and replicators (i.e., genes and memes) as beneficiaries of the achieved beneficial effects. The physical stance grasps incidental background lawful processes, while the function/design stance focuses on programmed mechanisms designed by selective processes (i.e., natural selection or learning/creating by trial and error). Here, the mind's sub-domains distinguish between assigning 'attained effects' to the first sort of system as a part of our intuitive physics, and 'beneficial function' or 'design' to the second type, as part of the intuitive engineering, intuitive functional morphology, and intuitive social role of an individual within a group. One can also distinguish between two varieties of agents: (1) agents with the means to pursue important pre-set general goals with relative efficiency without much representing, conceiving, premeditating, or resetting the goals, *versus* (2) agents that on top of that also are able to represent, conceive, premeditate, even reset their goals, and learn how to find the most competent way of achieving them via intermediary goals. Here, the teleosub-domains track the distinction between basic desired-goals as part of intuitive behavioral analysis (e.g., of prey/predators) *versus* belief as part of our more elaborated intuitive psychology/ethics.

Although far from exhaustive, **Table 1** offers a plausible starting point for considering the plurality of cognitive mechanisms generating thoughts about important recurrent aspects of our ancestral environment: Physical phenomena, tools/bodily parts/social role, prey/predators, and conspecifics. The last three of these cognitive mechanisms (design/functional stance, basic-goal stance, and belief stance) are genuinely teleological, and may produce acts of mental anthropomorphism. The common internal functioning among the three teleological stances is a presumption of rationality/optimization tiding together a predictive triangulation involving Desire/Need/Want/Goal/Aim, Perceive/Belief/Know/Situational Constraints, and Intentional/Deliberated/Volitional Action (Dennett, 1989; Gergely and Csibra, 2003; Hudson et al., 2018). However, there could be other teleological cognitive mechanisms not yet properly described/integrated. One suggestion is the intuitive, broad sense of purpose in life (Bronk, 2013), which is studied within eudaimonic well-being, related to a meaningful/virtuous life.

This section encouraged a pluralistic conceptualization for teleological reasoning that avoids essentialist thinking and presented a tripartite cognitive subdivision (design, basic-goal, and belief stances) prone to mental anthropomorphism. In order to attest the reality of this plurality and their presumed bio-psychological roots, the next section will explore the main cross-disciplinary factors of cognitive underpinnings of mental anthropomorphism, mostly the belief stance. This focus is needed because this mode of thought, which enables us to explicitly attribute and to consider higher order mental states, including false-beliefs and deception, has been well-studied across many fields for many decades. It started as "naive psychology of action" (Heider, 1958), but it was also named theory-of-mind (ToM, Premack and Woodruff, 1978), intentional stance (Dennett, 1989), folk psychology (Wellman, 1991), mindreading (Whiten, 1991), mentalizing (Frith et al., 1991), and cognitive empathy (Zaki and Ochsner, 2016). The rare studies focusing on the other teleological stances will also be covered.

## PROXIMATE AND DISTAL EVOLUTIONARY FACETS UNDERPINNING MENTAL ANTHROPOMORPHISMS

Here I highlight and integrate the main findings of each discipline about the sub-domains of folk teleology, mostly of the belief stance, and present evidence for their distinctions.

### Genetics

Twin studies have found modest to moderate heritabilities for tests of ToM, indicating some genetic variability underlying the individual variation in mentalizing and showing that environmental/cultural factors are responsible for the majority of the individual variation. Hughes and Cutting (1999) investigated 119 3-year-old twin pairs and found a 67% average estimate of heritability. The other 33% was explained by unique environment: the idiosyncratic child-specific factors non-shared within families. Hughes et al. (2005) found a 15% estimate of heritability for ToM in a sample of 1,116 5-years-old twin pairs. Ronald et al. (2006) assessed over 600 9-year-old twin pairs and found heritability of 12%, unique environment influencing 66% and shared environment influencing 22% of the variation. Melchers et al. (2016) found a 27% heritability for cognitive empathy in 742 twins and non-twin siblings.

In a meta-analysis, Warrier et al. (2017) investigated underlying genetics to ToM and its relation to other psychological traits and subcortical brain volumes. They performed genome-wide association in 88,056 participants, and additionally 1,497 twin participants. They confirmed a female advantage in mentalizing (Cohen's $d = 0.21$) which may be partly due to different genetic architectures in men and women, interacting with post-natal social experience. They found that a locus in chromosome 3 (3p26.2) is associated with the ToM only in females. They found an average twin heritability of 28%, while the other two-thirds is explained by the non-shared environment. However, heritability was positively correlated between males and females, which indicates general genetic communalities. Genes related to higher capacity for ToM correlated with openness to experience, cognitive aptitude, educational attainment, and anorexia nervosa. Although not significant, the same genes for increased ToM correlated with bigger dorsal striatum, which consists of the caudate nucleus and the putamen. One of the genes within the locus in chromosome 3 is the Leucine Rich Neuronal 1, which is highly expressed in the striatum, related to social cognition.

### Neuroscience

Neuroscience has discovered specific brain areas related with mentalizing both cortical and sub-cortical. Gallagher and Frith's (2003) review concluded that three cortical areas are consistently activated during tests of ToM: the superior temporal sulci, the temporal poles bilaterally, but principally the anterior paracingulate cortex. Abu-Akel and Shamay-Tsoory (2011) concluded that ToM primarily engages the dorsomedial prefrontal cortex, the dorsal anterior cingulate cortex and the dorsal striatum, and is dependent on the dopaminergic and serotonergic systems. Zaki and Ochsner (2012, 2016) concluded that mentalizing engages a specific system of midline and superior temporal structures (medial prefrontal cortex, temporoparietal, and superior temporal sulcus junctions), which are separate from empathic experience sharing. Overall, theory-of-mind's cortical profile is stably active at rest (within the 'default network' indicating spontaneity/readiness), and is related to autobiographical memory, detection of biological motion, mental navigation, 'self-projection' into the future, past, counterfactuals and targets' perspectives (Zaki and Ochsner, 2016). The sub-cortical portion, striatum, is related to social cognition and is activated by aversive/intense or novel/unexpected stimuli.

Lewis et al. (2014) investigated the neuroanatomy of subcomponents of eudaimonic wellbeing and found that 'purpose in life' is related to right insular cortex volume, and that there also was a marginally negative association with middle temporal gyrus volume. Thus, the neurocognition of 'purpose in life' seems to be different from mindreading. Reynaud et al. (2016) reviewed neuroscientific evidence on tool use, including planning and execution, which is related to the functional reasoning of design stance. They found brain regions, such as the left inferior parietal cortex, to be largely unrelated to those of ToM.

Importantly, Saxe et al. (2004) stated that neuroscience reinforces and elaborates upon the distinction between basic-goal and belief-goal cognitive systems by providing anatomical and functional evidence that domain-specific brain regions exist for representing belief contents, and that these regions are distinct from other regions engaged in reasoning about goals and actions. The temporoparietal junction, superior temporal sulcus, and medial prefrontal cortex show a strong activation for both true and false belief attributions. Conversely, brain regions involved in representing goal-directed action include the posterior superior temporal sulcus and Broca's area. Similarly, Mar et al. (2007) found that social processing brain areas are especially tuned to realistic visual representations of conspecifics, because the related cortical areas are more active when mentalizing about live-action social agents than about cartoon agents. This suggests that basic-goal stance and belief stance are two distinct systems, rather than variations of a single system (Saxe et al., 2004).

## Cognition

Mentalizing is cognitively demanding and requires focus. It can be disrupted into an egocentric interpretation by the absence of time, effort, and attention. This indicates that mentalizing is initially processed with the assumption that the self shares states with targets and latter it requires an effortful correction of the assumption (Apperly and Butterfill, 2009; Zaki and Ochsner, 2016). Bradford et al. (2018) found for individuals from both Western and non-Western cultures that self-oriented belief-attribution was faster and more accurate than other-oriented belief-attribution.

Importantly, several authors agree with the psychological distinction between basic-goal and belief systems (Wellman, 1991; Boyer, 2001; Gergely and Csibra, 2003; Baron-Cohen, 2005; Apperly and Butterfill, 2009; Edwards and Low, 2017). Nevertheless, the two systems are connected (Apperly and Butterfill, 2009). Based on ontogenetic and neurocognitive evidence, Baron-Cohen (2005) proposed that ToM receives input from the shared-attention system, which in turn receives inputs from systems focused on detecting emotion, intentionality (i.e., basic-goal stance), and eye-direction. Similarly, Schaafsma et al. (2015) disentangled ToM into tracking of intentions and goals, moral reasoning, separation of knowledge and fact, understanding of causality, and emotion/gaze processing. Moreover, basic-goal and belief systems share similar mechanisms. Gergely and Csibra (2003) proposed a common denominator to represent actions by relating relevant aspects of reality (action, goal-state, and situational constraints) through the principle of rational/optimal action, which assumes that actions most efficiently realize goal-states (cf., Hudson et al., 2018).

Based on neuroanatomical and neurochemical evidence, Abu-Akel and Shamay-Tsoory (2011) proposed three levels of cognitive functionality of ToM: representation, attribution, and execution/application of mental states. The ability to represent ToM may be lost by damage to posterior brain regions, particularly the temporo-parietal junction. The ability to attribute mental states to self or others and to distinguish between them may malfunction after damage to the dorsal attentional systems that integrate the temporoparietal junction and anterior cingulate cortex regions via the dorsal lateral prefrontal cortex. The manner in which the individual applies mental states, toward hypo- or hyper-mentalizing, may malfunction after disruption to lateral prefrontal cortex structures, particularly related to increased dopamine or to neurochemical processes that modulate its functioning, such as the serotonin system (Abu-Akel and Shamay-Tsoory, 2011). The latter is directly related to the over-attribution nature of mental anthropomorphism and is intensely studied in psychiatry.

## Psychiatry

Abu-Akel and Shamay-Tsoory (2011) linked ToM impairment to over 20 psychopathologies ranging across psychiatric, genetic and neurological disorders. Different psychiatric conditions present selective impairment in mind-reading, while the rest of cognition remains normal. This dissociation particularly between hypo- and hyper-mentalizing, offers strong evidence for modularization of mind-reading. A typical hypo-mentalizing disorder is degrees of autism/Asperger's spectrum, while schizophrenic individuals are diagnosed with hyper-mentalizing (Badcock, 2004; Brüne and Brüne-Cohrs, 2006; Crespi and Badcock, 2008; Abu-Akel and Shamay-Tsoory, 2011; Zaki and Ochsner, 2016). Thus, the execution/application component is calibrated along a continuum from low to high mental over-attribution. Moreover, Crespi and Badcock (2008) analyzed genetic, physiological, neurological, and psychological evidence as underpinnings of the psychotic-spectrum and proposed that maternally expressed genes promote hyper-mentalizing, and paternally expressed genes hypo-mentalizing.

Over-sensitivity to intention in schizophrenic individuals can take two forms: Positive, which underlies erotomania, or negative, which is much more common and relates to paranoia (Badcock, 2004). In schizophrenia, ToM deficits are repeatable, stable, heritable, have identified genetic markers, and distinctively disrupted neuro-functioning (Walter et al., 2011; Martin et al., 2014). Anthropomorphism in paranoid schizophrenia may result from either a mind-reading system that does not work properly or that is over-active (Abu-Akel and Shamay-Tsoory, 2011). Walter et al. (2009) found over-activity in the paracingulate cortex and the temporo-parietal junction to be associated with mental over-attribution in paranoid schizophrenics. Shermer (2011) concludes that patternicity may be associated with high levels of dopamine in the brain. He highlighted that increased dopamine is related to reward, pleasure, increased belief, pattern detection and false positives, and in higher doses triggers psychotic symptoms, such as hallucination and paranoia. Dopamine is also associated with enthusiasm and expectation (Shiota et al., 2017).

According to Baron-Cohen (2005), autistic children are able to represent the dyadic mental states of seeing and wanting (i.e., basic-goal stance) but show delays in shared attention and in understanding false belief (i.e., ToM). Atherton and Cross (2018) highlighted that ToM deficits in autistic individuals are ameliorated if the stimuli presented are cartoon or animal-like (i.e., basic-goal stance) rather than in human forms. Prothmann et al. (2009) found that autistic children (aged 11 years) interacted most frequently and for longest with a dog, followed by a person and then a toy. Furthermore, according to Badcock (2004) studies show that autistic children do not differ from others in their ability to understand the functions of an internal organ like the heart (i.e., design/functional stance). Moreover, autistic individuals have accentuated and precocious mechanical understanding and fascination with rule-based systems (i.e., physical stance) (Frith et al., 1991; Badcock, 2004; Baron-Cohen, 2005). Therefore, autism presents a case in which physical, design, and basic-goal stances are dissociated from the belief stance.

Similarly, Lombrozo et al. (2007) found that, compared to normal individuals, Alzheimer's patients broadly accept and prefer teleofunctional explanations particularly for the existence of living organisms (trees, dogs), non-living natural entities (mountains, sun), and natural phenomena (rain, wind). However, a review of evidence on ToM in patients with neurodegenerative diseases concluded that there is a deficit of the cognitive ToM component in Alzheimer's patients (Poletti et al., 2012). Therefore, this discrepancy provides further evidence that design and basic-goal stances are dissociated from belief stance.

## Development

In general, there is a well-defined, specific and universal ontogenetic route for understanding other agents. A meta-analysis on development of ToM using 178 studies found that false-belief performance showed a reliable developmental pattern across various countries and various task manipulations: Preschoolers went from below-chance to above-chance performance on false-belief tasks (Wellman et al., 2001). Beyond false-belief, Saxe et al. (2004) reviewed the literature and concluded that there is extensive evidence indicating that understanding other minds follows a characteristic developmental trajectory, beginning in the first 2 years of life with the early appearance of a system for reasoning about other's goals, perceptions, and emotions, and, around 4 years of age, starts the maturity of another system for reasoning about other people's beliefs. Similarly, Baron-Cohen (2005) placed the emergence of intentionality detection between 0 and 9 months and ToM at 4 years. Thus, very young children can attribute basic goals and desires much earlier than beliefs.

Ontogenetic evidence clearly supports distinct psychological mechanisms. Because brain regions associated with belief attribution are somewhat distinct from regions engaged with other people's goals, the two stages of development established in the literature result from differential maturation of two distinct mechanisms, rather than from gradual improvement of a single mechanism (Saxe et al., 2004). Gergely and Csibra (2003) agreed with this distinction and further argued that even 1-year-old infants possess a naive theory of rational action that allows them to interpret/predict other agents' goal-directed actions in a variety of different contexts using a non-mentalistic interpretational system. Csibra (2008) found evidence for goal attribution to inanimate agents in 6.5-month-old infants. Apperly and Butterfill (2009) reviewed evidence from development, cognitive sciences and comparative psychology and supported the existence of two agent-interpreting systems: An efficient but inflexible capacity for tracking basic belief-like states, that in humans persists in parallel with the later-developing, more flexible but more cognitively demanding ToM capacity. However, Onishi and Baillargeon (2005) and Buttelmann et al. (2009) used different tasks and found evidence for understanding false belief already in 15–18 year-olds.

Greif et al. (2006) found that children apply different logics to man-made artifacts *versus* animals: Children showed more curiosity about location and proper niche for animals but were more concerned with function and functioning for artifacts. Furthermore, children never asked what the animals were made for, which suggests that design stance and basic-goal stance are domain-specific separated mechanism. Keil (1994) found that second-graders preferred teleological explanations for biological kinds and mechanistic explanations for non-biological kinds. Concordantly, Kampourakis et al. (2012b) used open-ended questions and found that students provided teleological explanations for the features of organisms and artifacts but not for those of natural objects. Kampourakis et al. (2012a) argued that there is a conceptual shift in teleological thinking in which children up to 5 years show an unrestricted use of teleo-functional explanations, as found by Kelemen (2012) and Kelemen et al. (2013), but at later ages children use less teleofunctional explanations, mostly for parts of organisms and artifacts, and mostly for shape. However, future longitudinal research is needed to confirm this pattern (Kampourakis et al., 2012a).

## Ethology/Comparative Psychology

Evidence from our closest living relatives, the great apes, also supports the distinction between basic-goal and belief stances (Apperly and Butterfill, 2009). Call and Tomasello (2008) reviewed 30 years of comparative evidence and concluded that chimpanzees understand the goals and intentions of others, as well as the perception and knowledge of others. However, there was no evidence that chimpanzees understand false beliefs in terms of fully human-like belief psychology. Recently, Krupenye et al. (2016) and Buttelmann et al. (2017) used a modified task and demonstrated that great apes (chimpanzees, bonobos and orangutans) operate, at least on an implicit level, with an understanding of false beliefs, which lies already within the realm of the belief stance. Maybe in the future there will be evidence of belief stance in self-conscious animals. It is expected that we see a gradual instead of a sharp distinctions between humans and other apes, but until further replication one can conclude that the common ancestor of humans and chimpanzees 7.65 ± 1.01 million years ago (Pozzi et al., 2014) may have attributed basic-goals and desires to living agents much earlier than attribute beliefs. Moreover, reviewing evidence from 20 non-human species (mammals and birds), Emery and Clayton (2009) largely supported the distinction between basic-goal and belief stances, in concluding that non-human animals are excellent ethologists, but poor psychologists.

Wobber et al. (2014) did a cross-sectional and longitudinal study comparing physical and social cognition of 2- to 4-year-old human children and of chimpanzees (*Pan troglodytes*) and bonobos (*Pan paniscus*) in the same age range. They found that in physical cognition (space, causality, quantities), 2-year-old children and *Pan* apes performed comparably, but by 4 years of age children advanced and apes persisted at earlier levels. While in skills of social cognition (communication, social learning, theory-of-mind), children already out-performed *Pan* apes at 2 years, and increased the discrepancy even more by 4 years. They documented an emergence of goal understanding and of intention emulation at 2 years of age in humans and at 7 years or more in *Pan* apes. However, results comparing children and apes should be viewed with caution because of anthropocentric interpretative bias, inadequate controls and lack of ecological validity (Leavens et al., 2017). Nevertheless, this may indicate that the development of physical and basic-goal stances had different trajectories in humans *versus Pan* apes after separation from the common ancestor.

## Evolutionary Psychology

Teleology "arguably constitute[s] an evolved mode of interpretation built into the human mind" (Tooby and Cosmides, 2016, p. 14). Barrett (2015) stated that mindreading "has all the hallmarks of a complexly organized adaptive system: it likely evolved in steps rather than all at once, and it likely involves the interplay of multiple, specialized mechanisms" (p. 129). Indeed, as shown above, belief-stance possesses many properties of psychological adaptations: special design, underlying genetic variation, neurochemical specialization, cognitive modular integration, high efficiency/intricacy, functionality, developmental and phylogenetic dissociation from other domains, universal ontogenetic trajectory, cross-cultural universality. Given all the costs and drastic effects of minimal social interaction upon autistic individuals lacking mindreading, belief-stance also has benefits as a social instinct. Possible evolved functions of ToM are intentional communication, repairing communication, teaching others, persuasion, deception, devising shared plans and goals, sharing a focus or topic of attention, and pretending (Baron-Cohen, 1999; Brüne and Brüne-Cohrs, 2006). Smith (2006) argues that ancestral ToM enhanced social functioning and behavior prediction, and it facilitated conversation, social expertise, parental care, and deception. Thus, by improving detection, understanding, and forecasting of adult human behavior, the belief stance might have improved survival and reproduction (i.e., fitness). All of those possible ancestral adaptive values of ToM should be tested properly to qualify as truly adaptive advantages (Schmitt and Pilcher, 2004). Brüne and Brüne-Cohrs (2006) traced back the phylogeny of ToM and argued that it evolved from the capacity to monitor biological motion and from imitation behavior. Barrett et al. (2005) found cross-culturally that intention can be accurately perceived from visual motion cues alone.

Although less-studied, the physical, design, and basic-goal stances also provide evidence of special design, neurochemical specialization, cognitive modular integration, high efficiency/intricacy, functional, developmental, and phylogenetic dissociation from other domains, specific ontogenetic trajectory, and even older phylogenetic roots. All the available evidence supporting the distinction among the four stances affirms that they are specialized for tracking different, recurrent, and evolutionary relevant phenomena. The physical stance may have helped survival by improving understanding, forecasting, and coping with the physical world. The design stance may have promoted survival and reproduction by improving detection, use, and creation of functionality. The basic-goal stance may have benefited survival by improving detection, understanding, and forecasting of agents, particularly non-human prey and predators. Indeed, Csibra and Gergely (2007) argued that goal-directed reasoning promotes on-line prediction and social learning by drawing action-to-goal and goal-to-action inferences.

The fact that in nature time, energy, and resources are limited and that individuals compete is related to the evolution of the common underlying presumption of rationality/optimization (Dennett, 1989; Gergely and Csibra, 2003; Hudson et al., 2018) among the three truly teleological stances. In the face of limiting resources and competition, natural selection influences the evolution of fairly well-designed and roughly optimized body parts and behavioral strategies (Dennett, 1995; Ayala, 2016; Tooby and Cosmides, 2016), which have co-evolved with the perceptual and inferential abilities of design, basic-goal and belief stances (Hudson et al., 2018). Economy, efficiency, and functionality are among the hallmarks for identifying adaptations (Buss et al., 1998; Schmitt and Pilcher, 2004). Moreover, the optimal foraging theory explains the presumption of optimized choice for food in many species (Pyke et al., 1977). Hence, it makes sense that design, basic-goal and belief stances assume and yield rationality/optimality from body parts, behavioral strategies, and psychological tactics (cf., Schoemaker, 1991).

Importantly, there is a strong evolutionary reason for the adaptiveness of anthropomorphic tendencies. Rather than being a simple byproduct or another flaw in human cognition, propensity toward anthropomorphisms may be an evolved design feature. Guthrie (1993), Atran and Norenzayan (2004), Broaddus, unpublished, Beck and Forstmeier (2007), Shermer (2008, 2011), and Engvild (2015) explained the propensity to over-attribution using the 'better easily triggered than sorry' logic of Error Management Theory (Haselton and Buss, 2000): Because the costs of false-negatives in ancestral environments were much higher than those of false-positives, the underlying psychological mechanisms were selected to be biased toward the least costly mistake, hence false-positives abound. Not detecting harmful properties of parts of plants/animals or hidden traps on the way (design stance), of harmful movements of predators (basic-goal stance), or of an ambush and humans with harmful/cheating first or second intentions (belief stance) could be lethal. In contrast, over-detecting harmful functions, goals, or planned intentions where there were none would hardly be lethal. When we feel fear, many internal reactions occur, one of which is that signal detection thresholds shift. Less evidence is needed to trigger the threat response, thus more valid positives will be perceived at the low cost of a higher rate of false alarms (Tooby and Cosmides, 2008). Foster and Kokko (2009) tested this logic using evolutionary modeling and concluded that natural selection favors strategies that make many incorrect causal associations in order to establish those that are essential for survival and reproduction. Similarly, Brown et al. (1999) modeled optimality in prey-predator systems and found that one endpoint on an ecology of fear continuum favors the evolution of prey becoming more vigilant or moving away from *suspected* predators. Therefore, natural selection has made us more teleologically apprehensive and vigilant. This line of evolutionary reasoning can explain for instance why there is a brain component (lateral prefrontal cortex and dopaminergic system) devoted to the execution/application of mental states, why paranoia (negative intentions) is more common than erotomania, why people anthropomorphize more when alone or afraid, and why the striatum related to ToM is also activated by aversive/intense or novel/unexpected stimuli. Still, evolution is more than natural selection, thus other evolutionary factors may also play a role.

This section presented the main genetic, neural, cognitive, psychiatric, developmental, comparative and evolutionary/adaptive evidence pointing to the existence of the four distinct stances (physical, design, basic-goal, belief). Following Schmitt and Pilcher's (2004) framework for integrating evidence of adaptation, I have presented a comprehensive cross-disciplinary integration of results supporting the plural nature of teleological reasoning mechanisms. It also demonstrates that overly active calibration is possibly an evolved design feature to avoid harmful contexts that explains the widespread occurrence of anthropomorphisms. This confirms and expands the depth of the presumed biopsychological roots of mental anthropomorphism, and sets the stage for exploring the occurrence of anthropomorphism in philosophy of biology and teaching of evolution with the mosaic of three overactive psychological tendencies in mind.

# REUSE OF THE THREE ANTHROPOMORPHIC TENDENCIES IN UNDERSTANDING LIFE AND EVOLUTION

As part of our evolved intuitive/folk: physics, engineering/morphology/social contribution, behavior-reading and psychology/ethics; the four stances (physical, design, basic-goal, belief) inescapably get engaged while reasoning about modern science due to input similarities between the studied objects/processes and the evolved proper domains. In connection with other tendencies, those four systems exert a considerable influence on science matters, mostly on biology, but also on chemistry and physics (Kampourakis, 2007). This does not mean that biological science is less scientific, not objective neither that it cannot be materialistically explained (Mayr, 2004). Particularly, design, basic-goal, and belief stances are commonly related to the comprehension of processes and products of evolution by natural selection with negative and positive consequences.

On the positive side, they enable specialized scientific thinking by providing its cognitive foundations (e.g., inference, motivation, affinity) upon which academic competency is built (Geary, 2002). Moreover, relying on the three genuinely teleological stances while reasoning about biology and evolution leads to the pragmatic advantage of engaging a high-powered, acute, and skillful use of our minds; they easily organize data, explain interrelations, and integrate disparate topics (Dennett, 1989, 1995; Pinker, 2007; Haig, 2012). Lombrozo and Gwynne (2014) found that compared with a mechanistic mode of explanation (physical stance), properties of species and artifacts that are explained functionally (design stance) are more likely to be generalized on the basis of shared functions. Hence, they also promote generalization.

Furthermore, the heuristic value in terms of fostering new research questions and discoveries when asking for reasons, roles, goals, strategies, and values using "why?" and "what for?" questions is also crucial and documented (Schaffner, 1993; Buss et al., 1998; Dennett, 1989, 1995; Panksepp, 2003; Mayr, 2004; Haig, 2012; Tooby and Cosmides, 2016). Consequent metaphorical thinking helps researchers to model some processes/behaviors and use the grammatical construction of the active voice to didactically explain the dynamics to others (Ridley, 2003; Blancke et al., 2014; Galli, 2016). Even Darwin (1861) noted that 'natural selection' literally is a misnomer that implies the active power of a personified nature, but he argued that such metaphorical expressions are also found in chemistry and physics and added that they are important and almost necessary for brevity.

However, on the negative side, they can be involved in at least 8 classes of problems/controversies (cf., Mayr, 2004):

## Over-Activation-Without-Over-extension Type of Anthropomorphism

This occurs when there is over-attribution within the appropriate domain. For instance, attributing functional design to all aspects of a designed system, e.g., pan-adaptationism (Varella

**TABLE 2 |** Possible answers to a 'why' question about the behavior of four typical cases of material phenomena using all four modes/stances of thought, and its relation to kinds of anthropomorphic errors.

| Why does... | (1) Physical stance | (2) Design stance | (3) Basic-goal stance | (4) Belief stance |
|---|---|---|---|---|
| (IV) The woman speak? | Because she produces patterned sound waves | She is naturally designed to speak to better communicate | She just desires to speak now | She knows why she intends to speak about that now |
| (III) The ant walks? | Because of coordinated leg movements | It is naturally designed to walk to help foraging locomotion | It needs to follow the trail | It knows why it intends to seek food |
| (II) The heart beat? | Because of rhythmic contractions | It is naturally designed to pump to circulate the blood | It wants to pump | It knows why it is important to keep pumping |
| (I) The continent move? | Because of cyclical mantle convections | It is programmed to move to help speciation | It feels like moving | It knows why it should move |
| | | Gray area show corresponding over-activation-with-over-extension anthropomorphisms. | | |

**TABLE 3 |** Specific label to each over-activation-with-over-extension type of Anthropomorphic error.

| Mental stance in use | Type of phenomena focused | Type of error incurred |
|---|---|---|
| Design/functional stance | Physical phenomena | Promiscuous teleology<br>Pan-function compulsion |
| Basic-goal stance | Physical phenomena | Pan-agenticity |
| | Designed mechanism | Object Agenticity |
| Belief stance | Physical phenomena | Pan-psychism |
| | Designed mechanism | Object Psychism |
| | Animal behavior | Animal Psychism |

et al., 2013); attributing internal desire/need to all agent actions, e.g., fundamental attribution error (Granot and Balcetis, 2014); attributing intentional belief to all human actions, e.g., teleological obsession/over-active intentionality bias (e.g., Rosset, 2008).

## Over-Activation-With-Over-Extension Type of Anthropomorphism

This occurs when over-activation is directed to an inappropriate domain. Based on **Table 1**, one can try to explain all four groups of material phenomena with all four modes of thought and observe the types of anthropomorphic extrapolations whereby schema from a given stance are erroneously transferred to an unsuitable phenomenon. **Table 2** explores this insight by presenting all specific answers to a 'why' question through mapping the non-mutually exclusive proper and improper use of each stance.

Because the mechanistic/physical stance is non-teleological and answers a 'why' question as a 'how come' question, instead of 'what for' (Dennett, 2017), it never generates mental anthropomorphism. The design/functional stance generates anthropomorphism only when applied to non-designed physical phenomena (cell 2-I in the **Tables 2**, **3**), e.g., function compulsion (Kelemen and Rosset, 2009). Not surprisingly, most anthropomorphisms come from the cognitive devices focused on agent interpretation. The basic-goal stance generates anthropomorphism when used to explain non-agent systems (cells 3-I, 3-II). The intentional/belief stance may generate over-extended anthropomorphism when applied to all other domains (cells 4-I, 4-II, 4-III). By far the higher-order belief stance generates the majority of anthropomorphic acts given its narrow focus and high activity in a socially complex species such as *Homo sapiens* (cf., Wilson, 2012). Thus, the design, basic-goal and belief stances generate at least six different predictable acts of mental anthropomorphism. In **Table 3** I try to specify each occurrence of overextended type of mental anthropomorphism. **Tables 2**, **3** are important because, as Dacey (2017) argued, warning against 'anthropomorphism' in general is too vague to be helpful, thus the more we can identify specific errors, the better positioned we are to increase awareness of their occurrence and underlying causes, in order to avoid them. Dacey (2017) mentioned several variants of anthropomorphisms within the field of animal behavior.

The three teleological stances also may be extrapolated to other phenomena, fictional or non-fictional. Basic-goal and belief stances can animate fictional agents such religious, mythological, folkloric and extraterrestrial ones (Guthrie, 1993; Shermer, 2011; Blancke and De Smedt, 2013). The non-fictional phenomena that the human mind surely was not evolved to grasp and which involve basic-goal and belief stances include: the dynamic of the market economy, e.g., the invisible hand (appearance of intentional design in large-scale results of human unintended consequences of collective action), and natural selection (appearance of intentional choice in populational results of non-random differences in reproduction). Those two phenomena share some conceptual connection (Carey, 1998). Although metaphorically anthropomorphic, the use helps to better grasp these abstract population dynamic (Darwin, 1861; Dennett, 1995, 2017; Pinker, 2007; Blancke et al., 2014). However, the general hyper-active influence of basic-goal and belief stances on understanding natural selection is called "Darwinian paranoia," that is the propensity to think of all evolutionary outcomes in terms of an agent's reasons, plots, and strategies (Francis, 2004; Godfrey-Smith, 2009).

Interestingly, the distinction among design, basic-goal, and belief stances helps to explain specificities and to organize a variety of misunderstandings regarding selectionism and adaptationism. By stressing the centrality of function, the design stance may be mainly responsible for "naïve adaptationist" (i.e., conviction that function is the only explanation for why traits evolve) described by Kelemen (2012), and "if a trait is not an adaptation, it is not evolved" (Varella et al., 2013). By stressing need, attempt, and goal respectively, the basic-goal stance might be the main reason for mistaken explanations described by Kelemen (2012), such as "basic need-based" (e.g., giraffes got long necks because they needed them to reach high food), and "elaborated effort need-based" (e.g., giraffes got long necks through repeatedly trying to eat highly positioned leaves or fruit on trees) and "basic function-based" (e.g., "giraffes got long necks so that they can reach high food"). By stressing premeditated precise adjustments, the belief stance may be the main reason for mistaken "elaborated design need-based" explanations (e.g., giraffes got long necks because Nature transformed them so that they could reach food at the tops of trees, in order to survive) described by Kelemen (2012). In a systematic review, Varella et al. (2013) compiled 22 misunderstandings in applying evolution to human mind and behavior; two of them involve the conflation of basic-goal and design stances into belief stance. On "intentional maximization of fitness," the evolutionary gene's point of view (heuristic over-extension of the basic-goal stance) is equated to human personal intention. On "confusion between individual intention and adaptation's design," the functional design of mental adaptations is equated to personal intentions.

Gregory (2009) reviewed studies on the quality of understanding about natural selection and found that the reliance on 'need' appears in mistakes about the origin of new traits, inheritance, and adaptation. Of 42 studies he reviewed, at least 13 found mistakes attributing evolutionary/adaptive change in response to need, 11 found use and disuse, 6 found mistakes were related to want/intent, 4 to teleology, 3 to anthropomorphism, 2 to goal-directness, 2 to directed mutation. All of these mistakes mostly were influenced by basic-goal and belief stances. They combined incorrect underlying premises about mechanisms and deep-seated cognitive biases (Gregory, 2009). These findings indicate that important causes of widespread misunderstanding about natural selection are cognitive/psychological (Kelemen, 2012; Varella et al., 2013; Blancke et al., 2014). They are much deeper than lack of acceptance, media exposure, lack of formal education, or religious impediment (cf., Rosengren et al., 2012).

## Interaction With Other Psychological Tendencies Such as Perfectionism, Anthropocentrism, and Internal/External Distinction to Generate More Misunderstandings

Varella (2016) showed that different intuitive concepts such as fixism, essentialism, perfectionism and anthropocentrism easily could amalgamate with pan-adaptationism, and with each other, to form hybrid misunderstandings with a strong intuitive appeal. The conjunction of anthropocentrism and the design stance give rise to the common notion that 'humans exist in order to be the apex of evolutionary tree' (e.g., Sandvik, 2008) and that 'everything in nature is made to serve humans.' The mixture of pan-adaptionism, perfectionism and transformationism originates in mistaken 'cosmic teleology' (i.e., tendency toward progress and to ever-greater perfection; Mayr, 2004) and 'evolution as perfectionist' (Varella et al., 2013). Although fixist, Aristotle's original conception of teleology in nature (i.e., 'nature does nothing in vain') is a mixture of pan-adaptionism and perfectionism (Varella, 2016). It survived 24 centuries throughout history to be dismantled only by Darwin using non-teleological terms, such as randomness and genealogical inertia: the stamp of inutility (Solinas, 2015). However, the fact that Darwin discredited both creationist and Aristotelian teleology does not mean that he totally extinguished teleology in biology (Mayr, 2004; Ayala, 2016). "The irony is that Darwin's discovery of natural selection did not obviate seemingly "teleological" concepts; it legitimized them, by showing how and why the consequences of biological phenomena constitute an essential part of the explanation for their existence" (Daly and Wilson, 1995, p. 35).

Another amalgamation occurs between teleological reasoning and the intuitive internal/external distinction of causal factors. Gregory (2009) characterized anthropomorphic misconceptions as either internal (i.e., attributing adaptive change to the intentional actions of organisms) or external (i.e., conceiving of natural selection or "Nature" as a conscious agent. Likewise, Godfrey-Smith (2009) distinguished two explanatory schemata when anthropomorphizing nature: The paternalist [perfectionist] schema, a benevolent agent who intends that all is ultimately for the best, and the paranoid schema, a hidden collection of agents pursuing agendas that impede our human interests. Regarding internal amalgamation, it also may intermix with essentialism to originate "Adaptation equals gene" (e.g., gene for aggression) and "selfish gene equals selfish person" (Varella et al., 2013). Moreover, essentialism alone induces the focus on the individual rather than the population (e.g., individual organism changing/evolving; Gregory, 2009), so that it increases the odds of the basic-goal stance providing need-based explanations. This indicates that common Lamarckian mistaken interpretations about 'need' and 'trying' occur because students [and Lamarck] share the same intuitive bias rather than students being directly and deeply influenced by his theorizing. Kampourakis (2013) warned against the use of the label "Lamarckian" to inappropriately mask the variety of teleological explanations that students give, also because technically speaking, most of their explanations are not actually Lamarckian (Kampourakis and Zogza, 2007).

## Intuitive Folk Dynamics at Odds With Current Scientific Attitudes

Some authors claim that teleological explanations are more appealing and preferable to causal/mechanistic ones and would steer people away from 'how' questions, causal/physical modes of explanations, or empirical testing. Godfrey-Smith (2009) claimed that once teleological modes of thinking are turned on, they are difficult to abandon, because they have a compelling, addictive, and narrative appeal, and after starting to understand a phenomenon in terms of a persuasive rationale, people become reluctant to settle for less. The appealing narratives of agent stances may make people, including some scientists, readily satisfied with "just-so stories," but empirical verification should always be the gold-standard, even within the exaptationism program (Andrews et al., 2002). However, this problem should not be considered automatically as an inherent aspect of expert evolutionary reasoning in general (Varella et al., 2013). Godfrey-Smith (2009) also asserts that explaining life in terms of agents' agenda "makes sense" in a way that efficient causes cannot. Children possess a generalized bias in favor of teleological or purpose based explanations (Kelemen, 2012). Adults with poor inhibitory control in time-constrained contexts tend to broadly explain living and non-living natural phenomena by reference to a purpose (Kelemen and Rosset, 2009). Even physical scientists and humanities scholars accepted more unwarranted teleological explanations when working at speed, despite maintaining high accuracy on control items (Kelemen et al., 2013). However, Lombrozo and Carey (2006) showed that in less-constrained situations, teleological explanations are not easily accepted; only when the function invoked in the explanation conforms to a predictable pattern and when the function played a causal role in bringing about what is being explained. Heussen (2010) showed that when subjects focused on properties of body parts, causal and functional explanations were viewed as equally plausible, while for artifacts, causal explanations even were preferred over functional explanations. Richardson (1990) found that students tend to prefer teleological explanations 61% of the times over mechanistic explanations for body function, but after a short-term lecture with discussion regarding teleological and mechanistic thinking the preferences for teleological explanations were 12%. Thus, although there is a default bias toward purposeful explanation, there is also room for controlled, secondary modulation and inhibition through learning (e.g., Friedler et al., 1993). Moreover, Zohar and Ginossar (1998) showed that the acceptance of anthropomorphic or teleological formulations by high school students does not necessarily imply anthropomorphic or teleological reasoning, and the use of a textbook with numerous teleological/anthropomorphic formulations by biology students is not followed by an increase in students' application of teleological/anthropomorphic explanations.

## Conceiving All Versions of Anthropomorphism and Teleological Reasoning as Stemming Only From the Belief Stance/Folk Psychology

The lack of a clear distinction among the three cognitive systems of teleological reasoning (design, basic-goal, and belief stances) has led authors from one side to generalize it as a simply metaphorical but not a real explanation. The other side keep an overly suspicious view about any 'in order to' type of argument, denying it completely or even questioning the sanity of biologists. For instance, Mahner and Bunge (1997) clearly stated that in Biology,

> "we meet an almost schizophrenic situation. On the one band, many authors maintain that teleological concepts are legitimate in biology or are even constitutive of biology's (alleged) autonomy; on the other hand, they take pains to point out that biological teleology is somehow not a genuine teleology, but only an as-if-teleology, occasionally called 'teleonomy.' A similar contradiction can be found in the assurance that teleological explanations in biology could be translated into non-teleological ones, but eliminating teleology altogether would be impossible because "something would get lost" by doing so. Thus, biologists apparently cannot live with teleology but they cannot live without it either" (p. 367).

In the same vein J. B. S. Haldane famously said that teleology is like a mistress to a biologist because he cannot live without her, but he is not willing to be seen with her in public.

I argue that it is not the case anymore. Contemporary biologists do not need to hide their teleological proclivities nor disguise them as 'as-if-teleology.' Considering distinctions displayed in **Table 1** and Section "Proximate and Distal Evolutionary Facets Underpinning Mental Anthropomorphisms", it is clear that both the phenomena explained teleologically and the cognitive mechanisms used thereof are heterogeneous. Thus, beside the misattributions, there are plenty of genuine, legitimate, and literal uses of teleological explanations about functions, animal needs, goals, intentions, and lots of heuristic metaphorical uses of teleological clauses about natural selection, selective pressures, evolved strategies, and a gene's eye view that do not necessarily engage the premeditated belief stance, hence, strictly speaking they are not an *anthro*pomorphic mistakes. The fact the one can mistakenly interpret those same explanations as over-extending the belief stance (**Table 2**) does not mean that it is all that is.

When considering the belief stance as the only genuine teleology, and thus inappropriate for biology, one embraces an outdated high level of anthropocentrism that hinders nuanced multifaceted approaches. We now know that other animals also have needs, desires, goals and intentions (Allen and Bekoff, 1999; Panksepp and Biven, 2012) and that they perceive, attribute and process basic goals in conspecifics and other species (Emery and Clayton, 2009; Hudson et al., 2018). Thus, talking about the needs, goals and intentions of other primates or mammals is technically not *anthro*pomorphism (cf., Mitchell and Hamm, 1997). Furthermore, because tool use/manufacture appears across three phyla and seven classes of animals, with Passeriformes and Primates presenting diverse uses (Bentley-Condit and Smith, 2010; Shumaker et al., 2011), not even the classical 'watchmaker' type of designer analogical explanation should be considered *anthro*pomorphism anymore. Interestingly, although the basic-goal stance has evolved mostly to focus on animals, newer research indicates that plants sense, process experiences, memorize, learn, communicate and show adaptive behavior (Baluška and Mancuso, 2007). Thus, the new field of plant neurobiology (Brenner et al., 2006; Calvo, 2016) already is recruiting the basic-goal stance to heuristically interpret these findings, which exasperates critics, but again it is technically not *anthro*pomorphism. Overall, this is a promising case in which new convergent evidence from bio-psychology can help bio-philosophers (cf., Livingstone, 2017) to make updated conceptual distinctions clarifying new avenues of enquiry.

### Gateway to Mystic, Religious, and Conspiratorial Reasoning That Poses an Obstacle to Science

Only children show "promiscuous theism" (Kelemen, 2004), but Kelemen and Rosset (2009) found no link in adults between belief in God and acceptance of unwarranted teleological ideas. Lombrozo et al. (2007) found that patients with Alzheimer's disease have a robust preference for teleological explanations without the promiscuous theism, which indicates that promiscuous teleology is not a consequence of believing that everything was designed by a divinity nor leads toward it. The opposite seems to be the case, since the reduced belief in a God on autistic patients and in men is mediated by their lower mentalizing capacities (Norenzayan et al., 2012).

### Prohibition of All Teleology in Science

Although over-active teleological reasoning does not correlate or lead to religiosity, humans still have persistent teleological reasoning by default (Kelemen et al., 2013; Coley et al., 2017). Hence, in order to avoid the unwarranted forms of teleological anthropomorphism, science has become increasingly opposed to all types of teleology (cf., Nagel, 1961; Mahner and Bunge, 1997; Cummins and Roth, 2009), thus promoting anthropodenial (Mayr, 2004; Panksepp and Biven, 2012). However, once we realize that both the teleological phenomena and explanation are real and heterogeneous (**Table 1** and Section "Proximate and Distal Evolutionary Facets Underpinning Mental Anthropomorphisms"; cf., Dennett, 1989, 1995, 2017; Mayr, 2004), the possibility of 'throwing the baby out with the bath water' by prohibiting teleology becomes reality (cf., Zohar and Ginossar, 1998; Galli and Meinardi, 2011; Galli, 2016).

In general, for philosophy of science within the physicalist tradition, the anti-teleology movement means the correct rejection of animism, obscurantism as inherently non-scientific (e.g., Nagel, 1961), however, it may lead to issues of nomological reduction of all biological explanations, up to questioning the autonomy of biological sciences *per se* (Mayr, 2004; Ayala, 2016). In biology, anti-teleology means the correct rejection of vitalism (Mayr, 2004) leading to the precipitated rejection of the concept of a biological program (e.g., Mahner and Bunge, 1997). It also means the correct rejection of instructive models of adaptationism such as creationism, intelligent design, and Lamarckism (Cronin, 1993). But rejection may also lead to the long-standing dismissal of sexual selection and signaling evolution (Cronin, 1993; Miller, 2000), which are co-evolutionary processes guided by conspecifics although not fully thought-out by them. **Table 4** relates the contribution of each stance to the proper understanding of some evolutionary mechanisms. In psychology, the anti-teleology approach concerns the black box approach of early behaviorism and classical ethology by denying mentalistic terms, but also leads to denial of emotions, cognition, self-awareness and consciousness to other animals (Panksepp and Biven, 2012; Brejcha and Kleisner, 2016). According to Pinker (2007),

> "the biggest impediment to accepting the insights of evolutionary biology in understanding the human mind is in people's tendency to confuse the various entities to which a given mentalistic explanation may be applied. (...) More generally, I think it was the ease of confusing one level of intelligence with another that led to the proscription of mentalistic terms in behaviorism and to the phobia of anthropomorphizing organisms or genes in biology. But as long as we are meticulous about keeping genes, organisms, and brains straight, there is no reason to avoid applying common explanatory mechanisms (such as goals and knowledge) if they promise insight and explanation" (p. 138–139).

### Backfiring Prohibition of Teleology

While speaking of purpose and design in nature seems to strengthen the creationists' arguments, Dennett (2017) argues that to prohibiting all teleological reasoning as mere 'jargon' in biology can backfire badly. That is because by using the intuitive design stance anyone easily can find functions in the living world, and then conclude that biologists are reluctant to admit the manifest design because of the difficulty of explaining it without an intelligent designer. He suggests that instead of trying to convince lay-people that they do not really see the design they find in nature, we should rather try to persuade them that because of the cyclical, non-random and cumulative features of natural selection, there is real design in nature without a conscious premeditative all-knowing designer (Dennett, 2017).

This section explored the positive and negative aspects of the proper and overextended uses of the three teleological stances in relation to biological matters. I argued that recognizing the reality and distinctions among design, basic-goal, and belief stances is a key to illuminate and to better understand the logic underlying many of the issues involved: anthropomorphism, misunderstandings, seductive appeals, legitimacy controversy, gateway assumptions, prohibition, and its backfire effect. Importantly, the recognition of the multifaceted psychological nature of teleological reasoning enables new avenues for establishing a much more detailed taxonomy of anthropomorphisms (see **Tables 2**, **3**). The challenge now is how the recognition of the reality and distinction among design, basic-goal, and belief stances can help to alleviate most of the negative aspects.

## WORKAROUND EDUCATIONAL STRATEGIES

A better understanding of the three distinct deeply engrained neurocognitive teleological tendencies to anthropomorphize may help to illuminate ways of how to better deal, cultivate, canalize, and train them. Notably, their biological roots do not suggest that we should give up trying and embrace fatalism or naturalistic fallacy. As the biological nature of myopia did not deter the development of correcting glasses, the bio-psychological nature of teleological stances should assist us developing 'trifocal glasses,' in order to see clearly this tripartite distinction and to learn which one to use in which situation. Therefore, here I consider some strategies that are likely to succeed or fail in maximizing solutions to problems raised by anthropomorphism in philosophy and education.

**TABLE 4 |** Possible overlapping over-extended contributions of each of the four mental stances to correctly understand facets of some evolutionary mechanisms.

| | Physical stance | Design stance | Basic-goal stance | Belief stance |
|---|---|---|---|---|
| Genetic variation | Randomly caused* | Not directional | Not guided | Not premeditated |
| Natural selection | Non-randomly caused | Directional | Not guided | Not premeditated |
| Sexual/signaling selection | Non-randomly caused | Directional | Guided | Mostly not premeditated |
| Artificial selection | Non-randomly caused | Directional | Guided | Partially premeditated |
| Genetic engineering | Non-randomly caused | Directional | Guided | Highly premeditated |

*Randomly caused in the sense that it does not co-vary with fitness, not in a sense that it cannot be non-randomly caused by specific mutagenic factors.*

One strategy likely to fail is the suppression of all teleological reasoning (Zohar and Ginossar, 1998; Galli and Meinardi, 2011; Galli, 2016). That is because, as for the prohibition of drugs (Levine, 2003), abstinence-only sex education (Stanger-Hall and Hall, 2011), or suppression of emotion during decision-making (Lerner et al., 2015), it always finds a clandestine route back. Their suppression is counter-productive, and they reappears devoid of regulation, with lower quality and with worse consequences. By suppressing teleological thinking in biology classes, one also restricts intuitive thinking mechanisms that would better suit the problem, so it is neither feasible nor advantageous to deter teleological thinking (Zohar and Ginossar, 1998; Galli and Meinardi, 2011; Galli, 2016). As with biology, mathematics is not fully intuitive to humans, but numeracy intuitions intrinsically available are not abandoned or suppressed just because they may lead to error or they are incongruent with current knowledge; instead they are rigorously trained, refined, and connected with other capacities and thinking strategies (Geary, 2002; Apperly and Butterfill, 2009). Ideally, this approach also should be developed for teleological thinking in biology.

Varella et al. (2013) highlighted some strategies to better deal with evolutionary misunderstandings in the classroom: Considering previous knowledge, emphasizing critical thinking, explicitly approaching mistaken explanations and their presumed implications, stressing the interference of evolved cognitive biases (e.g., essentialism and teleology), and using structured-active learning. Similarly, Nelson (2008) suggested directly address misconceptions and student resistance, focus on scientific and critical thinking, and use structured active learning extensively as effective strategies for teaching evolution. Nehm and Reilly (2007) found that active learning was more efficient than traditionally taught class in reducing occurrence of misconceptions (also called alternative conceptions) about natural selection. Richardson (1990) found that one short-term lecture explicitly distinguishing between teleological and mechanistic thinking when applied to body function was enough to keep preference for finalistic explanations over four-times lower than in control classes. Within a one-semester biology course, Stover and Mabry (2007) found improved student understanding of natural selection after they monitored teleological language, carefully dealt with misunderstandings, avoided using wrong teleological explanations, offered laboratory/problem-solving activities, and presented historical context. Global attempts in this direction, such as the Biology Critical Thinking Project, seem effective and promising (Zohar et al., 1994). The development of questionnaires and inventories such as the Conceptual Inventory of Natural Selection (Anderson et al., 2002; Nehm and Schonfeld, 2008) can also help instructors to test the effectiveness of their intervention. As a way to control implicit anthropomorphic biases, Dacey (2017) proposed a check-list including items that stress alternative hypotheses that might explain the behavior and items that systematically help to identify errors. The more detailed taxonomy of over-attributing anthropomorphisms, suggested by this present multifaceted approach, may help the development such a preventative checklist.

Dacey (2017) also suggests that ensuring that counter-stereotypical information is saliently available for reasoning is an efficient way to avoid intuitive anthropomorphism. This strategy is exactly what Darwin did by using randomness and genealogical thinking to break with the notion that everything in nature is perfectly adapted (Solinas, 2015). Indeed, Kampourakis and Zogza (2009) found that first teaching about fundamentals, biological organization, mechanisms of heredity, and the origin of genetic variation helped to overcome students' preconceptions, and to achieve conceptual change. This change occurred because they put emphasis on the role of unpredictability and chance in the evolutionary process, which is incompatible with the idea of deliberated purpose/design in nature. Similarly, including historical processes (e.g., phylogenetic inertia) into the definition of adaptation may help students scrutinize intuitions about purpose and design in nature (Kampourakis, 2013). Within this strategy, educators should be aware that students may erroneously conclude that natural selection and everything in nature is random.

Many authors have explored non-suppressive teaching strategies aligned with the classical proposal to lift the taboos regarding teleology and anthropomorphism (Zohar and Ginossar, 1998). A specific strategy likely to succeed is to promote explicit control over the belief stance, circumscribing it and to decreasing its influence on the other stances' domains, in order for them to work alone. Dawkins (1986) famously made the watchmaker blind as a way to stay with basic-goal teleological reasoning without the premeditative thought-out side of belief stance. Dennett (2013, 2017) argues that stressing the existence of 'competence without comprehension' is crucial for understanding how natural selection can promote efficient functional design but without reasoned planning. Blancke et al. (2014) argued that the natural-selection-as-metaphor-of-designer after being dissociated from its intentional overtones actually may aid an initially teleological need-based understanding of evolution, which consequently may function as a scaffold to build a more scientific understanding. Similarly, Galli (2016) emphasized the explicit analysis of the metaphor of design, in order to promote student's meta-cognitive skills for recognizing, understanding, and regulating the metaphor of design in biology (cf., Galli and Meinardi, 2011). Legare et al. (2013) studied children's understanding of evolutionary change by comparing the effectiveness of using desire-based/anthropomorphic narratives (intentional mental states) with need-based (no reference to desires or conscious intent from the organism) and natural selection language. They found that need-based and natural selection language had similar positive effects, while anthropomorphic mental languages was worse for facilitating accurate interpretation. The multifaceted nature of the teleological reasoning into design, basic-goal, and belief stances legitimizes this pedagogical approach.

Complementarily, this multifaceted approach suggests that strategies aiming to focus on natural selection in the non-living or non-human domains could be promising, given that distinct mental systems would be activated. Metaphorically referring to natural selection as a 'goal-achieving system' such as a filter, an organ like a simple kidney, a Genome Organizing Device (Ridley, 2003), a sorting algorithm (Dennett, 1995, 2013, 2017), a bottom-up crane instead of a top–down skyhook (Dennett, 1995, 2013) may aid in achieving a more accurate understanding, by getting a stronger mental grip from the design stance, while inhibiting conclusions based on pure chance or pure top–down deliberation/premeditation. In the same vein, approaching natural selection as an simple agent, such as a mindless *bricoleur* (tinkerer) (Jacob, 1977), or mother nature (Dennett, 1995, 2017) could help to better engage the basic-goal stance, again avoiding pure chance or pure premeditation kinds of reasoning.

Another strategy derived from the adaptive value of over-attribution tendencies would be to lower the level of anxiety/fear during teaching and examination about natural selection. Also given that hyper-mentality is directly related to dopamine levels, which is associated with enthusiasm and expectation (Shiota et al., 2017), preparing 'super-engaging' classes also may be contra-productive. Educators should never forget to address teleological and anthropomorphic misunderstandings together with other sources of bias such as essentialism, perfectionism and progressivism. Moreover, for every 'why' or 'what for' question answered, a corresponding 'how' question also should be addressed in order to give a more balanced view between causal and functional factors (cf., Hogan, 2017).

Furthermore, educational strategies should not ignore gender. This is because as we saw, on average, women more than men tend to over-attribute faces (Proverbio and Galli, 2016), have higher mentalizing (Warrier et al., 2017), and empathizing (Baron-Cohen, 2005; Varella et al., 2016). Thus, they might be more prone to anthropomorphic misunderstandings. In fact, Cunningham and Wescott (2009) found that females more than males tended to agree that species evolves 'because individuals want to.' The same way mentalizing partly explains the higher belief in a god by females (Norenzayan et al., 2012), it might also influence their lower focus on Science (cf., Jones et al., 2000; Sjøberg and Schreiner, 2010). By not capitalizing on mentalizing, anti-teleological educational approaches might thus hinder female intuitive comprehension of biosciences. In order to better-tailor educational strategies that do not obstruct women's interest in science, future studies should control for sex, gender and cognitive style of the participants.

Future research should thoroughly test and replicate all those propositions and pin down the internal and external modulators of each over-estimating tendency, in context, in order to foster the development of better intervention strategies.

## CONCLUSION

In this review, I have presented a promising multifaceted approach to advance the debate regarding the psychological underpinnings of anthropomorphisms, to further support the materialistic and qualified lifting of the taboos regarding teleology and anthropomorphism in biology, philosophy and education, and to improve on pedagogical strategies aiming on maximize its positive sides and minimizing its negative aspects.

I firstly compiled and integrated 13 conceptual distinctions of folk finalistic reasoning into four psychological inference systems (physical, design, basic-goal, and belief stances), with the latter three being truly teleological, and thus prone to anthropomorphisms. I then integrated the cross-disciplinary genetic, neural, cognitive, psychiatric, developmental, comparative, and evolutionary/adaptive evidence that converges to support the existence of the four distinct stances. This exercise also revealed that the over-reactive calibration of the three teleological systems, which makes them more prone to anthropomorphisms, is possible an evolved design feature to avoid harmful contexts. This effort has confirmed and expanded the depth of the bio-psychological roots of mental anthropomorphism which indicates the unfeasibility of totally suppressing them.

Due to over-activation and input similarities between the studied objects/processes and the focused domain of each of the four stances (physical, design, basic-goal, belief), they inevitably get engaged while reasoning about modern science. Design, basic-goal, and belief stances have much to offer to biology: they provide cognitive foundations, express a high-powered explanatory system, promote functional generalization, foster new research questions and discoveries, enable metaphorical/analogical thinking, and didactically explain with brevity. This impressive positive side suggests that it can be valuable to find better ways to engage with their problematic sides and so legitimize responsible use. I showed that recognizing the reality and distinctions among design, basic-goal, and belief stances elucidates much of the logic underlying many of the issues/problems involved: Types of anthropomorphism, variety of misunderstandings, its seductive appeal, legitimacy controversy, gateway assumptions, prohibition and its backfire effects. Additionally, this multifaceted approach opens new avenues for establishing a much more detailed taxonomy of over-attributing anthropomorphisms, including distinctions such as bodily *versus* mental, legitimate *versus* illegitimate, with *versus* without over-extension, extended over each other stances' proper domains (**Table 3**) *versus* over new topics, fictional *versus* non-fictional new phenomena, pure *versus* combined with other biases, didactically promising *versus* problematic. Paraphrasing Pinker (2007), as long as we are meticulous about keeping straight design stance, basic-goal stance and belief stance, there is no reason to avoid carefully applying teleological reasoning to biology.

This line of reasoning stressing multifaceted stances is important because that it also offers a psychological substrate that is empirically based for anchoring definitions and terminology. Given that mental anthropomorphisms are addressed in different fields there is much variation in arbitrarily subjective definitions and inferences. Thus, an objective interdisciplinary approach grounded in the three teleological stances may make cross-fields discussions more profitable. Similarly, future experiments in education where researchers present teleological statements for students to judge should more precisely circumscribe each stance.

I hope this review usefully brings together related disparate academic literature in a way that offers the elements for fostering interdisciplinary discussion and research toward a more refined and bio-psychologically based way of thinking about anthropomorphism and teleology.

## AUTHOR CONTRIBUTIONS

MV conceived, researched, organized, wrote, corrected, and formatted the entire manuscript.

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# Anti-anthropomorphism and Its Limits

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There is a diffuse sentiment that to anthropomorphize is a mild vice that people tend to do easily and pleasingly, but that an adult well educated person should avoid. In this paper it will be provided an elucidation of "anthropomorphism" in the field of common sense knowledge, the issue of animal rights, and about the use of humans as a model in the scientific explanation. It will be argued for a "constructive anthropomorphism," i.e., the idea that anthropomorphism is a natural attitude to attribute human psychological features to other individuals, no matter they are actually rational agents, or not. If we know the "grammar" of this attitude, we can avoid the risks in overestimating the environmental inputs toward anthropomor-phism and, at the same time, take the heuristic advantages of anthropomor-phism in the use of human mind as a model for both everyday circumstances and scientific enterprise.

**Keywords: anthropomorphism, common sense, animal rights, ethology, comparative cognition, Morgan's canon**

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## 1. INTRODUCTION

There is a diffuse sentiment that to anthropomorphize is a mild vice, nothing really harmful, that people tend to do easily and pleasingly, but that an adult well educated person should avoid. This paper tries to inquire why it is so, and some limits of this latter statement. Note that this question would be ill posed, if anthropomorphism had been a plain logical mistake, as if people when anthropomorphize posit an identity between human nature and the other entity. This seems not the case, in general people who anthropomorphize is well aware that the entity at hand is not identical in nature with a human being, just that certain features, certain overt behaviors, or certain inner mechanisms, are shared. Therefore, there is no fundamental difference between anthropomorphism and common mental practices, like metaphorical thinking, where a selection of features of one domain are ascribed to a different domain. In thinking about a spaceship one assumes similarity between crossing world's open ocean and wandering in the wide space, that implies, for example, being equipped for long term self-sufficency.

It is out of the scope of this paper to review psychological theories of why people tend to anthropomorphize. A review covering theories from Heider's "attribution theory" to Humphrey's "natural psychology" and folk psychology is in Gallup et al. (1997), see also (Urquiza-Haas and Kotrschal, 2015). Rather, our aim is to identify domains in which anti-anthropomorphism is often applied, and to discuss the limits of such condemnation.

There seems to be at least three different domains mostly involved in the negative judgments about anthropomorphism, i.e., common sense knowledge and the role of intuitions in the scientific image of the world (section 2); the issue of animal rights and the anti-specism (section 3); and the use of humans as a model in scientific explanation (section 4). We argue that in all these domains anthropomorphism may work as a natural and frugal heuristics. It is, therefore, matter of elucidate how a kind of "middle way" could work and bring together, on the one side, the idea that anthropomorphism is literally wrong and, on the other side, the fact that it seems to be a natural and productive way of thinking. Arbilly and Lotem (2017) argue for a similar claim by their "constructive anthropomorphism." With their words: "We believe that the natural tendency of using our human experiences when thinking about animals (i.e., the tendency to anthropomorphize) can actually be harnessed productively to generate hypotheses regarding cognitive mechanisms and their evolution" (p. 2). In a similar way, the rationale of our proposal is to sketch out the main advantages to extend to possibility of this idea to the three areas above mentioned.

## 2. A NATURAL ATTITUDE

### 2.1. Common Sense Knowledge as a Two-Fold Creature

Anthropomorphism is held to be deeply grounded in common sense. Take into consideration how people often turn to mobile phones, cars or their pets. In all these cases we behave as if mobile phones, cars or pets had feelings similar to humans ("My phone is completely exhausted tonight," or, after running the risk of an accident, "This car really wants to kill me!"). Is there something instructive in this way of thinking so typical of common sense? Or, is it simply a childish attitude? There is a scholarly tradition of suspect against common sense, and often both philosophers and scientists take as the core of their businesses to challenge common sense believes. Sellars (1956), for instance, famously argued for a clash between the "manifest image" and the "scientific image" of the world. Intuitions, however, are often used by philosophers to support their arguments and to refuse the other ones. There is a controversy on this issue in the philosophical community (Cappelen, 2012). But, of course, all depends on what we mean by the phrases "intuition" and "common sense knowledge."

In this paper we suggest that common sense is a kind of ecological knowledge, which makes people fit in everyday circumstances. It is not only matter of popular beliefs shared with most of the people, but also of taking for granted something similar to the list of truisms in George Moore's *A Defense of Common Sense*: "There exists at present a living human body, which is my body. This body was born at a certain time in the past, and has existed continuously ever since…" (Moore, 1925, p. 65). On the whole, we suggest that common sense knowledge is to be considered as a two-fold creature (Perconti, 2013). It should be articulated into a "deep" and a "superficial" level. While the superficial level consists in judgments and beliefs which are culture-dependent, the deep level is made by implicit procedures grounded in human biology, that is, in motor habits, know how schemata, and bodily imagination. They are cognitive devices which seem to be (at least in part) culture-independent. For instance, the belief that "Berlin is a Central European capital" is part of the superficial level of common sense; and, taking from granted that the sun will shine again tomorrow is typical of the deep level of common sense.

In this perspective, anthropomorphism is considered as an adaptive natural mechanism grounded in the human brain and an instinct in the evolutionary history, which lead people to generate (sometimes illusory) representations that force us into selecting the appropriate data from the exterior world, and sometimes into overestimating the role of the environmental inputs rejecting a psychology of their own. This cognitive mechanism is at the basis of many aspects of the deep level of common sense knowledge, like these which lead us to treat mobile phones, cars, and pets as creatures endowed with feelings and intentions.

Anthropomorphism, in fact, basically is an attitude to attribute human psychological features, more than physical ones, to other entities. It is a psychologically and biologically based attitude to consider individuals as bodies ruled by unobservable forces. No matter if the target entity is really endowed with these features, or not. We can't keep us from using this scheme to give sense to our and others' behaviors. For this reason anthropomorphism is at the basis of pervasive social practices such as religious beliefs, loving pets, and comics.

### 2.2. Anthropomorphic Mental Triggers

In the environment there are several affordances able to evoke this attitude. Let's call them "anthropomorphic mental triggers," because they are responsible for the automatic activation of the psychological attitude called "anthropomorphism." Among the mental triggers which lead human creatures toward anthropomorphism, are included: (1) the predisposition to classify differently living from non-living creatures and to easily recognize emotional and personal characteristic features in biological motion; (2) the inclination to recognize meaningful faces in perceptive configurations; (3) the ability to joint attention with other people and to follow their gaze. Similarly to what happens in the "grammar" of visual perception (especially in the tradition of *Gestaltpsychologie*), in which were traced some of those "triggers" able to switch on the visual automatisms that complement the visual scene in a manner consistent with the way the environment is usually made up, also in the case of the "grammar" of the psychological attribution we should understand how these similar triggers work. When the "anthropomorphic instinct" starts up, triggered by the right affordances in the environment, we are forced to ascribe to that individual the same kind of inner life that everybody experiences in one's own introspection. Regarding the ability to automatically recognize whether a certain movement is living or not, and also to associate them a set of secondary traits, such as sex/gender or emotion, it seems that actually human brain processes specifically and automatically information about the movement of living organisms (Johansson, 1973). These latter, in fact, are endowed with kinematic features the human brain is particularly sensitive to. By isolating kinematic information from other perceptual features, Gunnar Johansson first discovered that humans are not only able to detect whether a certain kind of movement can be attributed to a living thing, but even if that thing is a man or a woman, if he or she is walking fast or slow, and in which mood he or she is. In addition to being processed on a selective basis, the information about the living movement is also processed in a spontaneous way by newborns (Simion et al., 2008). To sum up, it is matter of a skill which can be considered as typical of every human being. Another mental trigger for anthropomorphism is the capacity to spontaneously recognize a face in a given perceptual configuration. For humans, faces are the most significant perceptual configuration in which we can happen to come across. As in the case of recognition of the biological movement, even in face recognition the human brain is able to process such information selectively, automatically and very early in the development (Kanwisher et al., 1997).

Human newborns seem hardwired to social life through the spontaneous interpretation of the thoughts and emotions which are conveyed by faces. Sometimes this spontaneous attitude runs the risk to see more faces than actually there are. Everyone experienced having seen a face when, at a second glance, turned out to be nothing. Sometimes this physiological tendency in humans to overestimate the presence of faces in the world can take a pathological pathway, as in "pareidolia" (Hadjikhani et al., 2009). In a similar way, there are many other "pareidolia-like" cases of overestimating environmental cues, like in the cases of mistaken ascriptions of movements performed by not living organisms, or mistaken meaningful gazes to follow. The experimental results which comes from cognitive neuroscience suggest to consider recognizing faces as something that proceeds along two successive stages. At first, quickly and automatically, brain recognizes a certain perceptual configuration like a face. Then, it associates a set of personal type meanings, such as those linked to the rest of the things that we know about the person we are scrutinizing the face (Haxby et al., 2000). First brain identifiers a face and then, at a second glance, provides with the subjective meaning, making first experience of a "perceptual face," and then of a face provided with a meaning and a personal story.

The third mental trigger we have to consider is the ability to establish an eye contact with a given individual, and to divide the attention with him and a third part, i.e., gaze following and shared attention. From a developmental point of view, gaze following is prior to shared attention (Carpenter et al., 1998). As a result, in the case of shared attention we have not only a simultaneous act of visual attention, but a more complex joint attention event. Not only two individual acts, but one collective psychological event. With the Joseph Call e Michael Tomasello's words: "Joint attention is not just two individuals looking at the same thing at the same time. Joint attention requires that each of the individuals knows that the other is attending to the same thing as they are attending to; that is what makes it a joint, rather than merely a simultaneous, activity [...]. To engage in joint attention, therefore, an individual must at the very least be able to understand that another individual may see or attend to something" (Call and Tomasello, 2005, p. 45). The ability to follow other people gaze and to show interest in what seems to affect other individuals monitoring their attention is very early in typical development (Brooks and Meltzoff, 2002). This ability is essential for the communication development of children and for mentalization. In a word, without joint attention, there would be any intentional state or any language, and therefore ultimately any "society" in the human sense of the term. The above mentioned mental triggers prepare humans in a social direction on the basis of the spontaneous recognition of features which typically belong to a human being. Independently of any cultural encoding, humans are naturally led to consider as a person all individuals who happen to come across, to the condition—indeed quite liberal—that they fulfill the expectation to share attention, to express sense in their faces and to move in a way similar to other people. This natural inclination is toward human beings as well as toward not humans, and it precedes any subsequent cultural symbolization. Sometimes, in fact, we are inclined to treat as a person something which, at a second glance, we are forced to consider otherwise (for example, as an animal or a category of individuals not worthy of social respect). The natural inclination we are talking about is not responsible for the subsequent culture-sensitive judgments. Those judgments, in fact, are not based on the same logic which underlies the functioning of mental triggers.

## 2.3. Humanizing Technology

Althought, as we have just appreciated, anthropomorphism is a natural way to give sense to other people's behavior by means of the use of the intentional vocabulary, it is at the basis of scientific practices as well, like humanoid robotics, and developmental robotics (Perconti, 2013). To promote an ecological interchange between humans and robots, in fact, the designer has to take into account what is really able to facilitate a human-robot natural relationship. And, the best candidates for this role are again things like the ability to share other people attention, to follow their gaze, to express sense in their faces and move in a similar way to other organisms. For this, anthropomorphic attitude could inspire the computer scientists, when they are engaged in finding the right computational architecture to allow a humanoid robot to have a fruitful interaction with a real person. This ecological worry should inspire the attempts to humanize both robot's bodies and their minds. (Sandini and Sciutti, 2018, p. 2) stress the difference between "illusorily humanizing robots" and the challenge to make them more "humane": "A humane robot is a robot considerate of humans, that is, one that maintains a model of humans in order to understand and predict human needs intentions, and limitations, while being transparent, legible, and predictable. The ultimate robot may not be anthropomorphic, but it needs to have at least an anthropomorphic mind" It is interesting to note that the above mentioned attributive mechanisms, i.e., the anthropomorphic mental triggers, are good guides to design both humanoid bodies, endowed with the right mentalization cues, and humane robot minds, endowed with the same cognitive abilities to discover these cues in human overt behavior. The general point here is the possibility to consider anthropomorphism as a natural attitude to attribute human psychological features to other entities in order to give sense to their behavior. It is matter of a fast and frugal heuristics (Gigerenzer, 2007; Gigerenzer et al., 2011), which is actually able in everyday circumstances to easily find a way to categorize what is going on in the environment, like in the case you have suddenly to interpret the behavior of a threatening dog in the streets.

Furthermore, anthropomorphism works as a matrix to generate hypotheses on cognitive functions and their evolutionary history (Arbilly and Lotem, 2017). But, finally, we (both as scientists and common people) have to keep out to overestimate the presence of human psychological features into inanimate things and in other species. If not under control, anthropomorphism is, in fact, a danger because it conflicts with the principle of parsimony in psychology and, in general, in the scientific enterprise (Morgan's Canon, Occam's Razor, and so on; see below, section 3). But, if we buy the two-fold image of common sense, as above suggested to do, anthropomorphism appears to be a natural attitude regarding the deep level and both a danger (because it is literally wrong) and an opportunity (in the Arbilly and Lotem's sense) regarding the superficial level. This is exactly the "middle way" above and the reason why our anthropomorphism would be constructive in kind.

## 3. AN ALLEGED THREAT AGAINST ANIMAL RIGHTS

### 3.1. Specism and Empathy

There are specific reasons for anthropomorphism aversion related with the animal rights movements, curiously at two opposite ends. Anthropomorphism is seen by some supporters of animal rights as internal to specism, that tends to neglect the genuine features of animal species, conflating them in relation to humans only. On the contrary, enemies of animal rights movements accuse to make use of anthropomorphism in mistakenly ascribing sentiments, like feeling pain, to other animals. For these reasons anti-anthropomorphism is the right theoretical attitude in promoting the animal rights movements.

From a practical point of view, however, things are different. The feeling of empathy toward other animals is often driven by an anthropomorphic stance. This is exactly the reason why human empathy is usually about vertebrates, especially mammals, as they have similar physical features to human ones, like eyes, mouth, and biological motion. Human empathy toward these animals does not depend on any prior scientific knowledge on other animals' psychological skills, but simply on the link between anthropomorphism and empathy. And this latter, even nowadays, is actually the main engine of animal rights movements. Not long time ago, the scientific investigation of the other animals' mental faculties, if they experience pain and suffering, was still impossible. First reports on animal behavior were both anthropomorphic and anthropocentric in kind. Before the nineteenth century, what we knew about animals derived by and large from anecdotal stories. The anthropomorphic style and the use of anecdotes is typical also of Charles Darwin's writings. For example: "Dogs exhibit their affection by desiring to rub against their masters [...]. I have also seen dogs licking cats with whom they were friends. This habit probably originated in the females' carefully licking their puppies—the dearest object of their love—for the sake of cleansing them" (Darwin, 1872, p. 118).

Darwin's anecdotal style reflects his convictions on a line of continuity within the world of life, a continuity which also includes mental experiences. While contemporary scientific journals were overwhelmed by studies on mental abilities in other animals, mainstreaming scholars still refuse anthropomorphism. The anthropomorphic attitude was traditionally considered as a "cardinal crime" (Broadhurst, 1963, p. 12) or a "dangerous pit" (Breland and Breland, 1966, p. 3). But, doing so, we ignore the legacy of the *Expression of the Emotions in Man and Animals* (Darwin, 1872). Nowadays, however, Darwin is back and his quite liberal attitude is now grounded in the findings in the field of cognitive ethology (Urquiza-Haas and Kotrschal, 2015). Anthropomorphism fails when we do not have enough information on the biology, the evolutionary history and the ecology of the animal we are interested in. But, in the spirit of Darwin's writings, as well as Jane Goodall and Frans de Waal work, if you are aware of the ethological constraints of what we are saying, you can feel free to use our empathy to make a behavioral prediction and then to evaluate it. If the prediction will be right, then anthropomorphism is a good and fruitful attitude. Otherwise, you are aware the reasons why it does not success.

### 3.2. Anthropomorphism Without Shame

As we will see in section 4.2, anthropomorphism proved useful in the scientific explanation of what it means to be another animal. We observe that this progress has been beneficial from the standpoint of animal rights too. There are some areas of animal research that have drawn vital lymph from anthropomorphism, including animal learning, animal communication, the human/companion animal bond, and the applied ethology. Let us go into some detail. The field of animal learning received new lymph immediately after the abandonment of the behaviorist paradigm. The use of anthropomorphic projections on animal life has shown that a large part of animal behavior is teleological in kind and that animals are not only aware of their actions, but often able to evaluate the consequences of their actions. Many studies on animal communication achieved significant results only after abandoning the objective analysis of sounds and postures that animals adopted in their context. The scenario changed when the interest of scientists has moved on the message which the animal means, shifting the focus from the overt behavior to the mental life of the animal. Also the applied ethology, i.e., the use of principles and methods of comparative ethology and psychology aimed at modifying animal behavior and creating better environments for their lives, benefited from the use of anthropomorphic projections in scientific explanation.

The anthropomorphic turn in cognitive ethology enabled a concrete improvement of the captive environments. An example of this is the change in the type of housing for great apes that has greatly diminished behaviors such as listlessness, masturbation, and other behavioral abnormalities. Thanks to the empathic projection of our possible responses to captivity, the environments have been enriched with other animals, toys and other sources of stimulation. Anthropomorphism, of course, is especially useful with animals we share our daily lives, such as dogs, with which we shared our social world for over 12,000 years. Pets, in fact, have been accepted as an object of scientific study only in recent decades. For a long time, scientists have not considered farmers, livestock breeders and pet owners as a reliable source of information. They preferred long and costly studies and observations of exotic animals whose *Umwelt*, to quote Jakob von Uexküll (1921), was often unknown. Even in this case we have to consider Darwin as a forerunner of the contemporary way of conducting scientific investigations on animals. In order to develop his ideas on domestication, he included in his works the observations on his pets and many reports of livestock breeders.

Anthropomorphism, moreover, contains more methodological caution than can be believed. With the words of Charles Westley Hume, the founder of the Universities Federation for Animal Welfare: "If I assume that animals have subjective feelings of pain, fear, hunger and the like, and if I am mistaken in doing so, no harm will have been done; but if I assume the contrary, when in fact animals do have such feelings, then I open the way to unlimited cruelties. Animals must have the benefit of the doubt, if indeed there be any doubt." This kind of observations represents the way "constructive anthropomorphism" could show its advantages at the intersection of cognitive ethology and the movement for the animal rights.

## 4. HUMANS AS A SCIENTIFIC MODEL?

A third case where anti-anthropomorphism is often at home, is in philosophy of science. The idea that by eliminating every human perspectival element science will finally become objective is often found at the beginning of the last century. The dominant attitude at that time was a rejection of explanation in science altogether, as a form of anthropomorphism. The desire and need for finding explanations among humans is natural, but to push the concept of understanding beyond these psychological boundaries was held to be illegitimate. For scholars like Pearson (1911) the scope of science is to provide descriptions, better if in mathematical forms, not to explain anything. Carl Hempel reestablished explanation as the most precious achievement of science, by clarifying that justified explanations, purified from human perspectival elements, are those in the form of nomological deductive schemes. In *The Logic of Functional Analysis*, Hempel (1959) identified in functional analysis the alternative forms of explanation affected by the anthropomorphism virus, and therefore scientifically unacceptable. The negative attitude toward scientific explanation first, and functional explanation later, was a sensible rebellion against the long held idealist view that in order to explain natural phenomena one had to go beyond the limitations of science into some other realm such as metaphysics or theology. Today the majority of scientists and philosophers of science are immune from this temptation. Still, when philosophers of science praise for the search of scientific explanations at wide, often feel the need of a preventive defense against the accuse of anthropomorphism. For example Woodward (2003) in *Making things happen*, in defending his interventionist account of causation, includes a section titled *Nonanthropomorphism*.

While in scientific explanation in general the blame for anthropomorphism is mostly for indirectly invoking supernatural causes and purposes for natural phenomena, there is a domain where anthropomorphizing is more directly under accuse. It is comparative cognition. In this domain the worry about the ascription of human traits to nonhuman animals is today widespread and emphasized. For Wynne (2007) "anthropomorphism [...] should have no place in an objective science of comparative psychology, and Blumberg (2007, p. 145) argues that "Along with its fellow travelers—mentalism, introspection, and anecdotalism—anthropomorphism has infected the animal behavior literature."

### 4.1. Morgan's Canon

Like for scientific explanation in general, in comparative cognition too condemnation of anthropomorphism has a long history. Its sharpest and most influential verdict come from the so-called "canon" of Morgan (1894), prescribing that "In no case may we interpret an action as the outcome of the exercise of a higher psychical faculty, if it can be interpreted as the outcome of the exercise of one which stands lower in the psychological scale" (p. 53). Quite like for the case of Pearson's hostility toward explanations in science, Morgan's worries against animals' "higher psychical faculty" were raised in reaction against. In this case the target was the thesis of mental continuity of human and nonhuman organisms strongly held by Charles Darwin and George Romanes. In a famous and provocative passage Darwin (1871, p. 105) argued that "the difference in mind between man and the higher animals, great as it is, is certainly one of degree and not of kind." As we have already discussed in section 3.1, Darwin made large use of anecdotes about animal behavior, Romanes and other scholars were following his example. Even if Morgan rarely criticized directly Darwin or Romanes, his canon was used as a baton against the use of anecdotes and anthropomorphism in the study of animal behavior. There was an even deeper and older philosophical controversy behind the disagreement between Darwin and Morgan. Descartes (1641) articulated the idea of a sharp separation between human and nonhuman animals that mostly influenced Western culture. He developed an extensive description of organic functions in a purely mechanical manner, shared by humans and other animals, drawing a line between minded and unminded beings. In a perspective today dubbed as *mechanomorphism* (Mitchell et al., 1997), Descartes assumed that nonhuman animals are fully equipped with the mechanics necessary for surviving, but are devoid of mind and consciousness, thus lacking any form of feeling and sentience. The first radical opposition to Descartes was proposed by Hume (1739), advocating cross-specif uniformity in explaining animal behavior. The continuity between human and nonhuman animals was enforced by his empiricist view of the mind, structured by perceptual experiences. Darwin embraced an empiricist view of the mind largely inspired by Hume, while Morgan argued for a discontinuity between humans and animals, departing from the empiricist account of mind and behavior. According to Clatterbuck (2016) this fundamental divergence is the root of their different perspective on biology and on the methodology of animal behavior research.

It has been often remarked that, in fact, the standard application of the canon in comparative cognition has been flawed by its misrepresentation. Thomas (1998, p. 156), in referring that, according to Dewsbury (1984), Morgan's canon is "Perhaps the most quoted statement in the history of comparative psychology," cannot refrain from adding "that perhaps the most misrepresented statement in the history of comparative psychology is Lloyd Morgan's canon." The historical misuses of Morgan's canon concern mostly two issues: parsimony and anthropomorphism. The canon has been easily conflated with Occam's razor, advocating the explanation with the fewest assumptions. But Morgan was explicit in warning that the simplicity of an explanation is no criterion of its truth. As an example Morgan (1894, p. 54) cited that "to explain the higher activities of animals as the direct outcome of reason" is simpler "than to explain them as the complex results of mere intelligence or practical sense-experience." More often than not anthropomorphism can offer the most parsimonious explanation (Sober, 2005). In fact, as revealed by Thomas, Morgan had a very liberal view about anthropomorphism, stating that "First, the psychologist has to reach, through induction, the laws of the mind as revealed to him in his own conscious experience [...] Both inductions, subjective and objective, are necessary. Neither can be omitted without renouncing the scientific method" (Morgan, 1903, p. 48–49). An early observation of the failure resulting from an orthodox application of Morgan's canon was given by Hebb (1946, p. 88): "A thoroughgoing attempt to avoid anthropomorphic description in the study of temperament was made over a 2-year period at the Yerkes Laboratories [...] All that resulted was an almost endless series of specific acts in which no order or meaning could be found. [...] the use of frankly anthropomorphic concepts [...] provides an intelligible and practical guide to behavior." Despite its widespread misuse, Morgan's canon is still taught as a basic part of the comparative psychology curriculum, and still defended especially against the risk of anthropomorphism (Karin-D'Arcy, 2005).

Moreover, the attitude against anthropomorphism derived from Morgan extended well beyond comparative psychology, influencing to a certain extent ethology as well (Boakes, 1984). For sure, it is difficult to conceive Konrad Lorenz obeying scrupulously Morgan's canon when surrounded by his honking geese, or when communicating with his tame raven. In fact, ethologists were the first to see themselves as hampered by the strict compliance with anti-anthropomorphism. Hinde (1982, p. 76) complained that "Fear of the dangers of anthropomorphism has caused ethologists to neglect many interest phenomena." This rebellion grew during the encounter of ethology with cognition inside comparative cognition, as in the words of Griffin (1992, p. 152): "When one carefully examines such charges of anthropomorphism, it turns out that whatever it is suggested that the animal might do, or think, really is a uniquely human attribute. Such an assumption begs the question being asked because it presupposes a negative answer and is thus literally a confession of prejudgment or prejudice." Soon this new wave of freedom from the strict adoption of Morgan's canon called for reactions, John Kennedy (1992) devoted an entire volume to the condemnation of anthropomorphism, claiming that (p. 55) "Anthropomorphism must take its slice of the blame for a sort of malaise that has lately afflicted the subject of ethology as a whole."

## 4.2. Anthropomorphism and "Anthropodenial"

Despite Kennedy, in the last two decades the assessment of anthropomorphism in cognitive ethology from a philosophy of science perspective had progressed significantly. A new shared view is that applying anthropomorphism can lead to mistakes, as it would its rejection. However, since Morgan, only one type of error was taking into consideration: that of attributing certain human mental characteristics to a nonhuman animal that lacks it, the error called anthropomorphism. For the opposite error, of mistakenly refusing to attribute human mental states to nonhuman animals that actually do possess them, there is even no a name.

In an extended analysis of applying anthropomorphism in cognitive ethology de Waal (1999) introduced a possible name of this error, as "anthropodenial." Those to persist in the anthropodenial mistake are called by Keeley (2004) "antianthropomorphites." A useful metaphor of the error implicit in the systematic denial of human characteristics in nonhuman animal is given by Cartmill (2000) as "anthroporenalism." It is the (p. 841) "urological version of Morgan's Canon [which] would forbid us to interpret an animal's urine as the outcome of humanlike renal events—if we can find any other way of explaining it." The fact that no physiologist has never praised against the temptations of anthroporenalism is illuminating about the dose of Cartesian narcissism about our mental life, inherent to anti-anthropomorphism in comparative cognition.

Once established that anthropomorphism can be as misleading as anthropodenial in cognitive ethology, the next question is about possible methodological guidelines that allow to discriminate in advance when and how anthropomorphic attitudes are appropriate. De Waal suggests one discrimination, given by the level of anthropocentrism in anthropomorphism. When the view of the researcher is strongly characterized by the common taxonomy of human mental states and attitudes, easily leads to a form of anthropomorphism that naively attributes human feelings to animals without sufficient information. The opposite is what de Waal calls "animalcentric anthropomorphism," at work when (p. 264) "rather than being anthropomorphistic from a narrowly human perspective, ethologist mostly interpret behavior within the wider contest of species' habits and natural history." The concept of "biocentric anthropomorphism" offered by Bekoff (2000) is on the same vein, fostering the adoption of mental features common to humans, without a anthropocentric view. More recently, (Buckner, 2013) introduced a further *anthropo-* lexeme, that of "anthropofabulation," in defining the kind of anthropomorphism more prone to scientific mistakes which, much like for de Waal, is imbued by anthropocentrism. His term is due to the "confabulation about our own prowess" (p. 185) when studying nonhuman animal cognition.

A different answer to the quest for a methodological principle for a correct application of anthropomorphic hypothesis is given by Fitzpatrick (2008) as "evidentialism" (p. 242): "in no case should we endorse an explanation of animal behavior in terms of cognitive process X on the basis of the available evidence if that evidence gives us no reason to prefer it to an alternative explanation in terms of a different cognitive process Y—whether this be lower or higher on the 'psychical scale'." The principle has the merit to break the prejudicial asymmetry with respect to the two errors, that of mistaken anthropomorphism and that of mistaken anthropodenial, however is too general for being an effective methodological prescription. This is, instead, the aim of the "critical anthropomorphism" proposed by Gordon Burghardt (1991, 2007). The concept is derived from that of "critical realism" (Mandelbaum, 1964), and is the idea of adopting anthropomorphism in order to generate ideas that may prove useful in planning experiments and gaining understanding in the realm of animal cognition, with the awareness of the risk of drawing anthropomorphic conclusions that are erroneous. The "critical" component is applied by using other sources of information, such as natural history, physiological and neurological constraints, careful behavior descriptions, optimization models, and so forth. More precisely, when exercising critical anthropomorphism care should be applied in avoiding "anthropomorphism by omission," that is the failure to consider that other animals have a different world than ours (Rivas and Burghardt, 2002). A step further is taken by Timberlake (1997, 2007) by moving from anthropomorphism toward "theromorphism." This approach involves posing possible complex and human-like cognitive capacities in animals, but adopting an animal-centered view, in his own words Timberlake (2007, p. 142): "A theromorphic approach attempts to discover and represent important aspects of an animal's sensory and motivational worlds, thus allowing a human experimenter/observer to enter the animal's world."

The attempt to "enter the animal's world" is undoubtedly praiseworthy, but it is an effort intrinsically limited by our human cognitive status. This is but one reason for searching help in anthropomorphism. Probably one of the most viable strategy is to acknowledge that how humans cognition works is necessarily the best known model, therefore to make use of it just as a model. This is the sense of what Arbilly and Lotem (2017) calls "constructive anthropomorphism," and adopting the human model to animals may provide several advantages, in that (p. 2) "it forces us to consider complex cognitive abilities that are normally not attributed to animals, explain them using simple biological principles, and then, to carefully examine their possible application to animals."

Let us conclude by illustrating few cases in animal studies, where a "careful" application of anthropomorphism has lead to important discoveries.

von Frisch (1927) identified the famous "dance" performed by honey bees, interpreted as a communication code for informing hive-mates about the location of food just found. Von Frisch's discovery was hardly attacked for ascribing human-like communication abilities to insects, commonly deemed with very limited cognitive capacity. Critics of von Frisch later endorsed several alternative and less cognitively sophisticated explanations. One is that bees are simply conditioned to monitor and follow the odors emitted by returning foragers, with dancing just an irrelevant and unintended artifact with no communicate role (Wenner, 1998). In spite of that resistance, recent investigations have yielded new evidence of the complexity and flexibility of the honey bees dance (Gould and Grant-Gould, 1995; Seeley, 2003). Subtle variations in the way of indicating a direction distinguish between reporting locations of possible new hive sites or locations of food sources. Moreover, there can be comparisons between proposals of different locations, with bees first dancing signaling the source they found then following dancers describing a different source, and finally dance about the latter. In this case the term "dance" itself is just metaphor of a human behavior, but anthropomorphism is applied in hypothesizing a complex form of communication, and is applied as "animalcentric anthropomorphism," in that the communication medium and the aims of communicating are cast from the world view of the animal.

Unlike "dancing" for von Frisch, when Panksepp (1998) first wrote about "laughing" rats, he did use this verb with its literal meaning, for a behavior that is considered uniquely human. He noted a regular chirp in rats, with a trill type modulation around a frequency of 50kHz, seemingly related with positive emotional states. The following decades of research have yielded wide evidence supporting this bluntly anthropomorphic claim (Panksepp and Burgdorf, 2003; Burgdorf et al., 2005; Burgdorf and Panksepp, 2006). Not only do rats chirp when aroused to playful activities, paralleling children's playful laughter, they do the same also during tickling. Further, the same behavior can be elicited with electrical stimulation of the brain, on neural circuits involved in positive emotional responses, shared by most mammals, humans included.

Attributing laughing to rats is certainly not within the common sense anthropomorphism repertoire. As an opposite end we found "play," that is probably one of the preferred attribution of human habits to other animals by lay people, especially those keen on animals. This is one of the reasons that marginalized the scientific study of animal play: "having fun" is a too distinctively human feature. Niko Tinbergen (1963, p. 413) argued that play was too biased by "subjectivist, anthropomorphic undertones" to be seriously studied. By releasing anti-anthropomorphism worries, ethology progressed greatly the science of play, human playing included (Panksepp, 1981; Waring, 1983; Bekoff, 1984, 2001; Burghardt, 2005). Curiously, a recent line of research uses dog-human play as a testbed for studying anthropomorphism itself using ethological methods (Horowitz and Bekoff, 2007). The methodology is to classify behaviors by dogs in play and to compare with the behavior of projective anthropomorphizing by humans playing with them.

## 5. CONCLUSIONS

Anthropomorphism is, of course, literally wrong. But, it is also a natural cognitive attitude, grounded in the human biology and consisting in many natural inclinations that lead human beings to consider a certain individual in the world as a person, no matter if that individual actually is a rational agent, or not. As above argued for, anthropomorphism can be considered as a frugal heuristics both for everyday life and the scientific explanation. The constructive side of anthropomorphism is a major component in understanding that common sense knowledge plays an ecological role in everyday knowledge. Moreover, understanding the "physiology" of the use of anthropomorphism, and its advantages, also allows us to avoid the risks of its "pathology," hidden in overestimating those environmental cues, which are able to elicit the logical pathways which lead humans to see too much "human" in the world.

## AUTHOR CONTRIBUTIONS

Although all authors contributed equally to this work, DB worked mostly on section An Alleged Threat Against Animal Rights, PP mostly on section A Natural Attitude, and AP mostly on section Humans as a Scientific Model?

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# Anthropomorphism in Human–Robot Co-evolution

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Social robotics entertains a particular relationship with anthropomorphism, which it neither sees as a cognitive error, nor as a sign of immaturity. Rather it considers that this common human tendency, which is hypothesized to have evolved because it favored cooperation among early humans, can be used today to facilitate social interactions between humans and a new type of cooperative and interactive agents – social robots. This approach leads social robotics to focus research on the engineering of robots that activate anthropomorphic projections in users. The objective is to give robots "social presence" and "social behaviors" that are sufficiently credible for human users to engage in comfortable and potentially long-lasting relations with these machines. This choice of 'applied anthropomorphism' as a research methodology exposes the artifacts produced by social robotics to ethical condemnation: social robots are judged to be a "cheating" technology, as they generate in users the illusion of reciprocal social and affective relations. This article takes position in this debate, not only developing a series of arguments relevant to philosophy of mind, cognitive sciences, and robotic AI, but also asking what social robotics can teach us about anthropomorphism. On this basis, we propose a theoretical perspective that characterizes anthropomorphism as a basic mechanism of interaction, and rebuts the ethical reflections that *a priori* condemns "anthropomorphism-based" social robots. To address the relevant ethical issues, we promote a critical experimentally based ethical approach to social robotics, "synthetic ethics," which aims at allowing humans to use social robots for two main goals: self-knowledge and moral growth.

**Keywords: affective coordination, anthropomorphism, social AI, social robotics, synthetic anthropology, synthetic ethics**

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## INTRODUCTION

The idea of social robots has been inseparable from that of robots since its inception. In Karel Čapek's 1920 play "*R.U.R. (Rossum's Universal Robots),*" from which science and engineering inherited the term, the human-like artifacts called "robots" are artificial social agents that function as secretary, postman or factory workers (Čapek, 1920/2004). Compared to these fictional ancestors, today's social robots are quite different. For one, they are not bio-chemical, but mechanical artificial agents. Moreover, their social abilities do not arise spontaneously, as an apparent secondary effect of success at biochemically re-creating life. Generating the social skills of mechanical robots requires from actual "social robotics" (SR) highly specialized research in a variety of fields, original design and a complex process of implementation (Fong et al., 2003).

For the goal of SR is not to produce mere tools. Specialists in SR intend to build artificial agents capable of social performances that, in the perspective of their human users, can make them rise above the status of instruments to that of interlocutors (Kaplan, 2005). In a sense, this goal remains true to Čapek's fictional ideal of creating "artificial workers" engaged in a broad range of services – information, education, coaching, therapeutic mediation, assistance, entertainment, and companionship, among others. However, SR acknowledges that, to perform in these fields, robots need to exhibit many social behaviors and, in particular, to evince a believable "social presence," defined as a robot's capability to give the user the "sense of being with another" (Biocca et al., 2003), or the "feeling of being in the company of someone" (Heerink et al., 2008). It is here that SR most interestingly departs from the imaginary project that was at the heart of R.U.R.'s fictional robotics. Chapekian robots were almost perfect bio-chemical copies of humans, but Rossum had made slaves, 'animated instruments,' whose sociality he negated in an unsuccessful attempt to reduce these subjects to mere objects. SR aspires to do exactly the opposite: to allow mechanical objects to play the role of subjects, devising artificial agents that will not only be "tools," but also act as "social partners" (Dumouchel and Damiano, 2017). It is in the context of this project that we propose to consider the complex relationships between SR and anthropomorphism.

## SOCIAL ROBOTICS AS APPLIED ANTHROPOMORPHISM

### Reevaluating Anthropomorphism

Anthropomorphism is generally understood as the human tendency to attribute human traits to non-human entities (Epley et al., 2007; Złotowski et al., 2015), or to treat "non-human behavior as motivated by human feelings and mental states" (Airenti, 2015). As such, traditionally it has been viewed as a bias, a category mistake, an obstacle to the advancement of knowledge, and as a psychological disposition typical of those who are immature and unenlightened, i.e., young children and "primitive people" (e.g., Caporael, 1986; Fisher, 1996; Mitchell, 2005). In contrast to this traditional negative evaluation, SR grants anthropomorphism a positive, and plurally articulated, role. The fact is that the tendency to anthropomorphize is quite frequently manifest among humans, and thus the goal of building social robots suggests that it may be used as a tool to facilitate social exchange between robots and humans. The underlying idea is to actively involve users in the social performances and presence of the robots, by designing robotic agents that stimulate users to attribute human feelings and mental states to robots, which should enhance familiarity and promote social interactions. However, if anthropomorphism is an infantile and primitive character trait, the question arises: is it legitimate for SR to exploit what must essentially be viewed as a human failing?

It should be noted that, though it persists in more or less ambiguous forms (e.g., Caporael, 1986; Kennedy, 1992; Mitchell, 2005; Wynne, 2007), the negative evaluation of anthropomorphism has received challenges from many disciplines. For example, evolutionary anthropology and the cognitive science of religion developed a more positive conception of anthropomorphism as a cognitive device that augmented human fitness. It is argued that the tendency to see human faces or bodies in ambiguous shapes provided important fitness advantages to early humans, helping them to distinguish between friends and enemies, to rapidly recognize predators, and to establish alliances with other tribes (Guthrie, 1995; Bering, 2005). Anthropomorphism would then be an evolutionary adaptation that, according to many authors, is inseparable from religion and is often associated with the existence of a Hyperactive Agency Detection Device (HADD) (Barrett, 1998; Westh, 2009). This re-evaluation of anthropomorphism is reinforced by recent findings in cognitive sciences, which question its classic (for example, Piagetian) psychological understanding that confines anthropomorphism to the early childhood, and essentially views it as a cognitive mistake (Airenti, 2015). This new conception argues that anthropomorphism constitutes a fundamental and permanent dimension of the human mind, rather than an early stage of its cognitive development, that is grounded in neural mechanisms also found in other older species, and which is modulated by individual traits (Duffy, 2003; Złotowski et al., 2015; Levillain and Zibetti, 2017).

### Modulating Anthropomorphism

In order to successfully utilize anthropomorphism, SR has been exploring its underlying mechanisms, and how interactive robots can trigger and regulate them. Therefore, a significant part of its research enquires into the conditions of activation of anthropomorphic projections. The focus is on two key factors, human-like (anthropomorphizing) appearance and autonomous movement or behavior (Levillain and Zibetti, 2017). The basic hypothesis is that strong realism *in either* of these two factors allows a robot to reach the "social threshold" where humans experience its presence as that of another social agent and are disposed to socially interact with the machine. This implies that a highly anthropomorphic robot can produce that social effect even when behavioral realism is low, and, vice versa, that behavioral realism will lead to anthropomorphic projection even in the absence of a human-like appearance. Things, however, are not quite that simple, in particular, the relation between the two factors appears to be asymmetrical. When the threshold is reached in result of human-like appearance only, and the movements or behavior of the robots prove inadequate – that is, inconsistent with the anthropomorphic projection – a sudden "non-linear" effect in terms of familiarity and social interaction will take place. In robotics, the best-known example of this is "the Uncanny Valley" effect hypothesized by Mori (1970), in which an increase of human-likeness raises a robot's likeability until the resemblance becomes nearly perfect. At that point, conjectures Mori, takes place a strong negative emotional reaction and a rejection of social interaction; the robot strikes its human partner as a strange, uncanny object. This sudden change, as we argued elsewhere, is the result of a mismatch between resemblance and movement – a dissonance stemming from unrealistic movements and behavior in a highly human-like robot (Dumouchel and Damiano, 2017). Furthermore, as experimental findings show, the discrepancy between resemblance and movement functions in the opposite direction when it is, so to speak, inverted. When there is little or no human resemblance but high behavioral realism, the effect on likeability and social presence tends to be positive. When any object begins to manifest, for example, autonomous coordination with a human's movement, the person is inclined to socially interact with the object even in absence of human-like appearance. These results, consistent with empirical evidence from psychology (Urquiza-Hass and Kortschal, 2015), suggest that realistic behavior dominates human-likeness in activating anthropomorphic projections.

## 'Good' Anthropomorphism: Ascribing vs. Inferring

Research in SR tends to emphasize the plural articulation of anthropomorphism (Duffy, 2003). Interestingly, it stresses the difference between the form of anthropomorphism occasioned when one interacts with social robots, and anthropomorphic projections evoked by other types of objects, such as traditional dolls, cars or computers (Levillain and Zibetti, 2017). This difference is generally described in terms of the cognitive activity involved. In the second case, the subject *ascribes* human traits to non-human entities, while, in the case of social robots, *infers* these traits from the behavior of the non-human entity. Note that this distinction partially overlaps the difference between the two factors analyzed above: on the one hand, the static human-like (anthropomorphizing) appearance of the robot seems to correspond to the simple ascription of human traits, while, on the other, the dynamic realism of autonomous movement appears as the basis of the inference from behavior.

This distinction between different forms of anthropomorphism is also important to understand the ambiguous relationship that SR entertains with anthropomorphism. Inasmuch as it is inseparable from a comparative evaluation of the two forms, this distinction reveals a partial re-alignment with the negative attitude that remains dominant in science (Złotowski et al., 2015). Projected anthropomorphism is viewed as based on a fallacy and receives a negative evaluation, while anthropomorphism that is inferred from, or triggered by, the autonomous behavior of robots is positively evaluated. It is argued that it is based on empirical evidence which provides a potentially plausible explanation of the phenomenon. Notwithstanding this mildly self-serving argument – SR rests on anthropomorphism, but only on the 'good one' – the distinction corresponds to a valorization of the research and technical efforts dedicated to creating social robots, and to an attempt to determine the difference between common artifacts and the anthropomorphizing machines that are social robots.

## Applied Anthropomorphism: Social AI

The project of endowing robots with social traits, or making them able of social "performances," does not require robots to understand the performed task, nor to have the social "competences" and "properties" that underlie this understanding (Pfeifer and Scheier, 1999). If this project takes its origins in classic AI, the development of a particular field of robotics dedicated to creating social robots was strongly influenced by the "Embodiment turn" in the cognitive sciences (Damiano et al., 2015; Dumouchel and Damiano, 2017). This supposedly 'paradigmatic shift,' which emphasized the role and importance of the body and of the environment in the cognitive competence of agents, also led to giving greater attention to the social environment as a fundamental factor in cognitive competences and development. In consequence, emerged within SR a new approach to artificial intelligence that can be defined as 'social AI' – and not simply "artificial social intelligence." Its goal is not merely to artificially reproduce the 'social intelligence' of human agents. Indeed, its central claim is that human intelligence is essentially social. The roots of this hypothesis go back to a well-established trend in the cognitive sciences (Humphrey, 1976) and primatology (de Waal, 1982; Byrne and Whiten, 1988) arguing that human intelligence emerged from the need of solving 'social problems.' However, over the years it abandoned its early focus on deception and manipulation, which characterized it when it was named "Machiavellian Intelligence." It granted growing importance to the role of cooperation characteristic of human intelligence and social interactions, as opposed to other primates (Chapais, 2008; Tomasello, 2008; Hrdy, 2009). The procedure adopted in social AI is to use human social competences, and the interactive and cooperative dimension of human intelligence, as models to develop similar performances and abilities in robotic agents. These attempts at tailoring on ours the social and cognitive performances of robotic agents are equivalent to attributing human traits to robots by implementing them. This 'applied anthropomorphism' inverts the metaphor that guided classic AI for more than 50 years. Rather than seeing in the computer the model of the human mind, SR uses human social and cognitive competences as a model for the social and cognitive performances of artificial social agents. Finally, the applied anthropomorphism of SR typically constitutes a synthetic approach (Pfeifer and Scheier, 1999) to the subject.

## Anthropomorphism as a Method: 'Synthetic Anthropology'

Exploiting different combinations of these various forms of anthropomorphism, SR produced a wide range of artificial social agents. They can be seen as belonging to a 'triangular spectrum,' whose vertexes can be exemplified with three kinds of robots: (i) robots like Paro[1], whose realistic animal-like appearance encourages anthropomorphic projections, in spite of its limited social AI; (ii) robots like Jibo[2], whose appearance is not conducive to anthropomorphism, but which nonetheless gives rise to such projections because of its sophisticated social performances; and (iii) robots like Affetto[3], whose anthropomorphic appearance is matched by high level social AI. It is important to note that all social robots, independently of where they are located on this spectrum, tend to reach the threshold at which, in the eye of the user, objects become subjects. This is indicated,

[1] http://www.parorobots.com/
[2] https://www.jibo.com/
[3] https://spectrum.ieee.org/automaton/robotics/humanoids/meet-affetto

or at least strongly suggested, by research on human users' representations of social robots (Kahn et al., 2002; Severson and Carlson, 2010; Turkle, 2011; Gaudiello et al., 2015). Empirical results show that social robots tend to blur the traditional ontological categories that humans use to describe the world. More precisely, these results show that not only children, but also teenagers, adults and the elderly perceive social robots as ambiguous objects, which transgress the boundaries of traditional ontological categories and dichotomies. They are viewed neither as "sentient" nor as "not sentient," neither as "intelligent" nor as "not intelligent," neither as "alive" nor as "not alive" (Kahn et al., 2002). According to researchers, interactive computational technologies bring people to revise the ontological categories they use to classify objects that, like social robots, are located somewhere in between the terms of the old dichotomies – objects that are "sort of alive" or "alive enough" (Turkle, 2011). Human users attribute them a status that is somewhere in between, one that does not clearly fall on either side of these dichotomies.

The ambiguous status of social robots became the origin for a new scientific endeavor, whose relevance grows as the comparison between humans and social robots yields ever more ambivalent results. As the frontier between humans and robots is progressively blurred, the question of what constitutes human identity, or particularity, is raised anew. On this basis, anthropomorphizing robots make possible a novel science of human beings (Parisi, 2014), in which they (robots) function as both 'objects' and as 'instruments' of an inquiry about "what is human?" (Kahn et al., 2007). The central idea is that of an innovative comparative ethology and psychology. Instead of trying to understand the human species through its similarities and differences with other animal species (Tomasello, 2008), this new comparative science uses as terms of comparison the changing abilities of robots. Hiroshi Ishiguro's "android science" (Ishiguro, 2006; MacDorman and Ishiguro, 2006; MacDorman et al., 2009) occupies a leading place in this line of research. The original inspiration, which stems from classic AI, is interpreted by the embodied approach of SR and realized through the anthropomorphic robots it builds. This offers the possibility of comparatively studying human minds as one among other "embodied minds." Applied anthropomorphism, as practiced by SR, thus acquires the position of the central research method of a new science of human beings. This is a kind of 'synthetic anthropology' that promises to expand our knowledge of ourselves through systematic comparison with our increasingly sophisticated doubles.

Despite the unquestionable scientific interest of this new research direction, related technological applications in SR raises questions. Current literature emphasizes how highly human-like robots can be perceived as menacing by users, especially when they appear able to perform better than humans (Yogeeswaran et al., 2016) and display autonomy (Złotowski et al., 2017). According to the "threat to distinctiveness hypothesis" advanced by Ferrari et al. (2016), the increasing blur of boundaries between robots and humans destabilizes the perception of "human uniqueness," and tends to generate growing concern on the negative impacts of this technology (Ferrari et al., 2016).

## Ethics: The Anthropomorphic Imposture of Social Robots

The anthropomorphism of social robots is considered to entail a variety of dangers, which span, for (vulnerable) users, from cognitive and psychological damages to manipulability and reduced quality of life[4] (Lin et al., 2012, e.g., chapters 4, 12, and 15). Among these criticisms, there is an ethical concern that denounces the use of anthropomorphism to create social bonds between humans and robots, and judges it unacceptable. This denouncement, which rejects and condemns the applied anthropomorphism central to SR's project, acquires relevance in that it orients current attempts to ethically regulate robotics[5].

Sherry Turkle, among those who extensively investigated human–robot interaction through ethnographic research, is one of the most eminent voices of the ethical concerns raised by anthropomorphic robots. She grounds her argument on two important dimensions of social robots. First, to the extent that they are "relational artifacts," the anthropomorphizing design of social robots presents them as "artifacts that have inner states of mind" and interacting with them is assumed to involve "understanding these states of mind" (Turkle, 2005, p. 62). Second, ethnographic studies focusing on children and the elderly indicate that social robots are also "evocative artifacts," which foster the emergence of affective bonds that users tend to describe as reciprocal love and care. Anthropomorphizing robots, argues Turkle, presses our "Darwinian buttons"; they activate responses typically related to strong affective relations, such as the nurturing instinct in children, or memories of old loves in the elderly. On this basis, they mobilize high emotional charges and create an "illusion of relationship" (Turkle, 2007, 2011 p. 514). The main idea of Turkle's ethical criticism of the use of anthropomorphism in SR is that social robots constitute a form of "cheating" technology. Their anthropomorphizing characteristics tend to falsely convince their users – especially the most vulnerable ones – that they can provide *real* social relations, with *genuine* and *reciprocal* affect and emotions, while they simply cannot. Thus, Turkle sees in social robots a further step in the development of our "culture of simulation," which threatens to turn people away from "real" social relationships – that is, from relationships with other humans – and reduce their social life to an illusion – to the feeling of being together with someone, when in fact one is alone. She concludes her radical criticism of all anthropomorphizing computational technologies by claiming that they "should not be allowed into the realm of human relationships" (Turkle, 2010, p. 4).

One interesting, and significant, aspect of this way of conceptualizing the ethical issue – which is in fact quite common – is that it relies on oppositions, for example 'authentic/simulated' or 'true/false,' which many years ago were used to question the validity of classic AI. The question that was then asked was: "Do computers really think, or do they just

[4] http://www.milkeninstitute.org/events/conferences/global-conference/2016/panel-detail/6182

[5] https://www.epsrc.ac.uk/research/ourportfolio/themes/engineering/activities/principlesofrobotics/, http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-/ (Principle 4, License for Designers, Point 11).

simulate thinking?" The efforts to answer, and to confront these dichotomies, ultimately led to the distinction between "weak" and "strong" AI. The AI that simulates and fakes it, and the AI that promises to deliver the 'real thing.' In relation to SR and social AI, the questions are: "Do anthropomorphizing robots expose their users to authentic or simulated social behavior? Is love expressed by a robot 'real love', or is it 'simulated love'?" Turkle's answer is that "simulated thinking may be thinking, but simulated feeling is never feeling, simulated love is never love" (Turkle, 2010, p. 4). We believe that SR's applied anthropomorphism both allows and requires us to address these questions, as well as the ethical concerns raised by social robots, in a different way.

## ANTHROPOMORPHISM AND SOCIAL COORDINATION

### Anthropomorphic Projections as Action

Anthropomorphism, as applied by SR, challenges the traditional understanding of the phenomenon in a variety of ways. Rather than seeing it as a cognitive mistake, SR views anthropomorphism as a fundamental tool in successful human–robot relations. Rather than condemning anthropomorphism as an unjustified attribution of mental states to inanimate objects, SR exploits it to create artificial agents that challenge the subject/object divide. However, as we have just seen, anthropomorphism, in its traditional form, comes back to haunt SR as the ethical criticism of the design and use of social robots. Implicit in that criticism is the conviction that anthropomorphic projections correspond to false beliefs. The mistake involved can be benign when the commitment to the false belief underlying the projection is weak. For example, when we say: "the weather doesn't want me to go shopping today." Come to think about it, we do not *really* believe that the storm *wants* anything. However, Turkle and others argue that this mistake can have important consequences when the false belief becomes entrenched or gains strong motivational force. For example, when children believe their robotic caregiver sincerely cares for them, the danger, according to Sharkey and Sharkey, is that robots tend to exploit, and even amplify, "children's natural anthropomorphism" (Sharkey and Sharkey, 2010, p. 164).

We are not sure if robots amplify "natural anthropomorphism" or not. We certainly agree that SR exploits it, as our arguments in the previous sections show. However, we do not think that "natural anthropomorphism" is proper to children, nor that it is or rests on a cognitive mistake. Recent studies in psychology (Epley et al., 2007, 2008; Timpano and Shaw, 2013) and in neuroscience (Scheele et al., 2015) recognize that anthropomorphism is closely related to human sociality. They retain nonetheless the traditional conception of the phenomena, and consider that anthropomorphism is primarily a question of (false) beliefs. They then inquire into the social conditions – for example, lack of, or poor, social relationships – that encourage people to attribute mental states to non-human animals and objects (Paul et al., 2014). In this context anthropomorphism is viewed as a form of compensation, a way of dealing with solitude, or a reaction to the loss of a loved one – a sign that something is amiss. SR, on the opposite, considers it as a central aspect of sociality, and tries to harness its pragmatic and relational dimension.

If you ask a friend to borrow his jigsaw and, as he hands it to you, he adds "Be careful, it is a bit temperamental!", how should you interpret this remark? It is unlikely that you will conclude that he sincerely believes that his jigsaw has moods, mental states and other psychological dispositions. If you do, you will have misunderstood the nature of the interaction. The point is not that this use of language is metaphorical. Rather it is that, by attributing to the other this outlandish belief, you fail to recognize what he has just done: to warn you and recommend care. Isn't "Be careful!" enough? By adding "It is a bit temperamental!", he directs your attention to the fact that his warning concerns the use of the jigsaw, that he is not so much worried that you will damage his machine as your own work while using it, and he recommends you to treat it gently. "Gently." Another metaphor? The anthropomorphic use of language is not metaphorical here, because there is no corresponding literal way of saying it that would accomplish what his warning and recommendation do.

Even if it were possible to describe in detail the types of circumstances in which the jigsaw reacts strangely, the forms of its unexpected reactions, and the necessary precautions, such a list is not equivalent to a warning and recommendation. It is not an action, not a performance, but a description. While the list leaves you free to follow its indications or not, the more detailed it is, and the more it constrains your behavior, instructing you what to do. Though the your friend's warning may exert a certain social pressure upon you, because it simply directs your attention to the "temperamental" character of the jigsaw, it leaves it up to you to find out how and when to be careful. Thus, the anthropomorphic language reaffirms what is implicit in lending you the jigsaw, that its owner trusts you. It treats you like an agent in an interaction, unlike a set of instructions that can govern a machine.

### Interacting With Agents

Anthropomorphic statements should not primarily be understood as descriptive statements, but as pragmatic statements in the context of interaction. As such the projection does not need to rest on the attribution of mental states to the anthropomorphized entity, nor imply any false belief. When someone says about her car, or computer, "It does it on purpose!", she does not believe that her car is an intentional agent or that her computer hates her, and thus breaks down when she needs it most. What she attributes, or rather recognizes, is the changed role of these objects within the interaction. Breaking down 'agentifies', so to speak, the object. It transforms the object from a dependable mechanism, which regularly fulfills its function, into an agent or a subject – that is: into something whose behavior is to be explained in relation to itself. The best, and most familiar, models we have of such entities, and of interacting with them, are other humans, and social interactions. Spontaneous anthropomorphic projections take place when we discover that we are now dealing with an entity that needs to be explained in relation to itself, rather than simply in relation to our own goals and purposes. More precisely, it corresponds to the recognition that we are interacting with an entity whose behavior is, to some extent, determined by itself – an agent.

Anthropomorphic projections do not rest on the prior belief that an object or animal has human like mental states. It rests on the recognition that one is dealing with an entity that acts – even if it only 'acted up', so to speak – and that the relation has changed, from, say, a relation of use to a form of interaction. That is: to a relation that requires the coordination of the actions of two 'agents' for any one of them to be able to achieve his, her or its goal. Anthropomorphism is the recognition of 'inter-subjectivity' in action. Our claim then is that a large class of anthropomorphic statements are expression of the mechanism underlying what Trevarthen and Delafield-Butt (2017) describe as "primary" and "secondary inter-subjectivity": the ability to coordinate one's action to those of another. This ability is already present in very young infants, and does not, in any way, require the attribution of beliefs. It rests on basic neuronal mechanisms, and constitutes a fundamental building block of who we are as social and cognitive agents. According to Trevarthen, primary and secondary inter-subjectivity do not disappear as the child matures, but are integrated as necessary elements in "tertiary consciousness of inter-subjectivity."

Anthropomorphic projections do not require, nor necessarily imply, the belief that a non-human animal or object has mental states similar to ours. Nonetheless, in many cases, they will lead to the formation of such beliefs, which may or may not be true. Historically, the term 'anthropomorphism' has been reserved to refer to when the attribution fails, and the belief is false. Yet, there has been, and there still is, uncertainty as to when that is the case. For example, whether or not, and to what extent, it is legitimate to attribute beliefs, desires, or emotions, like fear or loneliness, to a dog, a cat, a horse, a monkey or a lobster, are issues on which there is no universal agreement. Not so long-ago behaviorists thought that attributing mental states to human beings was unscientific, and some philosophers even argued that we should discard the mentalist language of folk psychology and replace it by one derived from neuroscience (Churchland, 1996). Yet, in action, if not in their writings, all adopted the intentional stance when interacting with others. Anthropomorphism is primarily a tool for interacting, not a description of the world.

## Affective Coordination

Turkle's claim – "simulated thinking may be thinking, but simulated feeling is never feeling, simulated love is never love" – rests on an understanding of mind and emotion that is closely linked with the conception of anthropomorphism as false belief. This view was originally crafted by Descartes (1641/1998) and Descartes (1649/1989), and its dualist conceptual structure, in spite of repeated denials, was inherited by contemporary philosophy of mind, mainstream cognitive science and AI (Damiano et al., 2015; Dumouchel and Damiano, 2017). According to Descartes, mind and body are two radically different substances. Thought, the 'action' of the mind, consists in reasoning performed by an immaterial soul. In cognitive science, this soul becomes an abstract mathematical entity, and thought the computations it executes. Just as the soul transcends matter, the computational mind is indifferent to 'that' in which it is implemented, given the required functional equivalence is maintained. Given, to put it otherwise, that the system is implemented *as such*, or as the system that it is, the matter in which it is implemented does not matter. Thus, that artificial agents may think – "simulated thought may be thought," as Turkle concedes – is perfectly consistent with this conceptualization of mind.

According to Descartes (1649/1989), feeling and emotions are produced by the body. They are events that take place internally, in the intra-individual 'space,' where the epistemic subject 'resides.' Thus the mind perceives – or rather experiences – them directly. In consequence, the emotion produced by the body, and experienced internally, can never be false – it is always genuine. There is, however, a second aspect of feelings and emotions: their external expression. Relative to the emotion itself, produced and experienced internally, its expression is secondary and contingent, for the subject can suppress the expression, or even fake (simulate) having an emotion he or she does not have. The expression is external: it is a public event, in inter-individual space, and others can perceive it. Here, in this social space, emotions can be either true or false, simulated or genuine, depending on the relation between the expression and the subject's internal state.

This way, the first dichotomy, the body/mind divide, leads to a series of other dichotomies, which reproduce the original valuation that exalts the mind above the body, and computation beyond mere matter. Production/expression, internal/external, private/social, necessary/contingent, but also genuine/simulated, and true/false: whatever is on the left-hand side of the slash is deemed superior to what is on the right side. We may think that we have abandoned Descartes's dualism. However, it is clear, from Turkle's claim, that we did not abandon the dichotomous way of thinking we inherited from him.

Within this conceptual scheme, the emotions expressed by robots can only be false, simulated, inauthentic, because robots lack the internal emotion that is the warrant of the truth and authenticity of affective expression. Attributing feelings to social robots constitutes a form of anthropomorphism. It rests on the false beliefs that these machines have internal states that correspond to the emotion they express – an illusion that they tend to encourage.

In SR, based on the "affective loop approach" (Damiano et al., 2015), an "emotional" robot is defined by its capacity to engage users in a dynamic interaction that includes affective expressions and appropriate responses triggering further reactions on the part of both the human and its artificial partner. The goal is to make "the user [affectively] respond and step-by-step feel more and more involved with the system" (Höök, 2009), in a way that enhances the robot's social presence and favor human–robot social interaction (Paiva et al., 2014). This goal can be achieved with either of two kinds of robots. The first kind simply expresses emotions by realistic appearance and motion. The second kind combines these expressive skills with social AI to manifest "intelligent expression," that is, emotional expression coordinated with that of their users.

An interesting aspect of these successful implementations of the affective loop is that they violate two fundamental assumptions of the 'Cartesian' approach (Damiano et al., 2015). First, they do not treat the robot as an 'individual,' that is, an independent affective agent whose emotion is essentially internal and private. The target of the affective loop is not to produce emotions within the robotic body, but to create a recursive human–robot emotional dynamic that generates robotic emotional expressions in – more or less 'socially intelligent' – artificial agents. The goal is to coordinate the affective expression between human and robotic agents. The second difference is that, within this affective exchange, the robot's expressions do not communicate pre-existing emotions. They function directly as a means of generating human emotions. They trigger immediate emotional reactions that do not need, or rest on, the complex process of interpretation which philosophy, psychology, and classic cognitive sciences postulate as necessary for a person to access others' emotions. This affective coordination bypasses both theory of mind and folk psychology. Applied anthropomorphism does not require any false beliefs.

The robots developed by the affective loop approach illustrate a different conception of emotion, which can be traced back to Hobbes (1650/1994). Since then, it remained present, though somewhat marginal, in philosophy. Recently it has been 're-evaluated' by embodied cognitive science, and received support from the discovery of mirror neurons and related mechanisms (Rizzolatti et al., 2001). This view proposes to consider affect as an evolved mechanism of coordination between agents (Dumouchel, 1999). The fundamental hypothesis is that affective expression is part of a continuous process of inter-subjective coordination, in which agents reciprocally determine each other's emotions and dispositions to action. Within this dynamic, expression and determination of emotion are inextricably entangled, and cannot be separated. Affective expression is a direct mean of influence among agents in interaction, which contributes to the mutual specification of their dispositions to act. Far from engaging in a rational calculus (or simulation) aimed at discovering the emotions of others, agents participating in inter-subjective interactions directly co-determine each other's emotional state. Recent results suggest that this process of emotional co-definition may be supported by "mirroring mechanisms," which do not only couple perception and action, but also perception and the expression of emotion. Indeed, mirror neurons fire not only when a subject expresses an emotion, but also when he or she observes another person expressing it.

Within this different conception of emotions, the oppositions that are commonly used to understand and evaluate emotional interactions are destabilized. Here mind and body converge, production and expression of emotion are entangled, and, when applied to emotions, the classic dichotomies – internal/external, private/public, genuine/simulated, true/false – are neither clearly defined, nor constitute perfect oppositions (Damiano, 2009; Damiano et al., 2015). Human–robot interactions, as implemented by SR's affective loop approach, repudiate the classic thesis that conceives true emotions as internally produced and experienced private events.

## FROM 'DICHOTOMOUS' THINKING TO 'SYNTHETIC' ETHICS

### From Condemnation to Impotence

The main weakness of the common view, when used to judge the ethics of SR, is that it leads us to consider all SR's projects in the same way – as resting on a form of deception and thus as 'unethical.' Its only coherent position is a radical condemnation of all social robots, and of all anthropomorphizing technologies, which "should not be allowed into the realm of human relationships." However, this simple equation between 'simulation' and 'imposture' is not only unable to account for fundamental ethical differences, but also tends to misrepresent them. Consider, for example, the two following projects: robotic companions built to help autistic children develop social skills, and sex robots that have an integrated 'rape option.' In the first case, there are issues concerning the illusion of a reciprocal caring that need to be raised. In the second case, putting the emphasis on 'fake rape' may lead to defend rather than to condemn the practice – "What's wrong with it, it does not hurt anyone?" – but also misses the central difference. In the first case what is aimed at is to empower vulnerable persons, while in the second case the effect is to encourage rape, making it banal and meaningless.

The blanket condemnation of anthropomorphizing technologies and social robots, in turn, condemns ethics to impotence. Social robots will not go away, their development will not stop. What recommendations can a wholesale condemnation provide? What questions can it answer? What dialog is possible between SR and such a form of ethical reflection? Presently, the greatest danger is for SR and ethic reflection on SR to develop in two separate theoretical and epistemological spaces: severing SR from ethical inquiries and reflections that can directly participate to the "new science of human beings" (Parisi, 2014). What SR needs are meta-level ethical analyses leading to guidelines that help it maximize the benefits and minimize the dangers of the construction and integration of artificial social agents in our social ecologies. That is why it is urgent to develop a different form of ethical reflection for SR. An ethics that shares SR's interactionist embodied approach, and, while recognizing the irreducible (epistemological, phenomenological, operational, etc.) differences that distinguish human–robot from human–human interactions, grants to our exchanges with social robots the status of a new, specific, certainly limited, but genuine, form of social relationships.

### Synthetic Ethics

This form of inquiry will be attentive, and able to respond to aspects of SR's projects that the dichotomous approaches fail to grasp. Creating anthropomorphizing robots that aid autistic children to develop social skills is miles away from trying to help them by creating the illusion of a reciprocal relationship. Within the different view of emotion sketched above, this project appears as an attempt to address malfunctions in some aspect of these children's mechanism of social coordination by appealing to other aspects of that same mechanism – in particular to the spontaneous ability at anthropomorphic projections. Such a re-interpretation would constitute the starting point of an ethical inquiry aimed at defining ethical guidelines for this kind of projects, some of which would of course relate to the child–robot relationship, the conditions for it to be genuine and the necessary precautions to be taken.

This new framework provides a significantly different understanding of the second case considered above. From the point of view of affective coordination, sex robots with an integrated 'rape option' do not offer to human users to 'simulate rape.' Rather they invite users to engage in rape *tout court*, because the proposed practice is embedded in a social context, even though it is one that is mixed – a human–robot social context. As mentioned earlier, human users tend to perceive social robots as interlocutors that break the object/subject divide. They tend to recognize these robots as a new category of interactors, with whom they can establish social relationships. If that is the case, raping a robot is still rape, the violation of an agent, even if the artificial agent does not react to this violation the same way a human does. To the extent that robots are truly becoming social agents, participating in our everyday life, developing an embodied interactionist ethics is urgent.

In previous works we introduced, under the name of "synthetic ethics" (Damiano, 2015; Dumouchel and Damiano, 2017), the lineaments of this new approach. Also we argued that the applied anthropomorphism of social robots offers the possibility of deeper self-knowledge, and can be an occasion of moral growth (Coeckelbergh, 2012). The basic idea is to extend the 'synthetic anthropology' that is already emergent in SR by applying to ethics in SR the "understanding by building" or synthetic approach (Pfeifer and Scheier, 1999). We refer to "ethics in SR" because the ethical issues concerning social robots do not arise at the border where robots meet society at large. It is not a question of applying new scientific and technological developments. Ethical issues are part and parcel of the very development of this applied anthropomorphism. Synthetic ethics incorporates human–robot interactions in experimental scenarios, analyzing emergent behaviors from an ethical point of view to deepen our knowledge of humans, and of the spontaneous and changing ethics (mores) of human–robot interactions. This knowledge can then be used to review and improve the practices of robots, and to inquire into the ethical (and political) opportunities and dangers of their integration into our social ecologies. The focus should be on the concrete problems that social robots create, or are likely to create, as well as on those issues that can productively be addressed using social robots as research instruments and co-objects of exploration. In short, the applied anthropomorphism of SR can also be a method of inquiry in ethics. This means that the ethics of SR should not be reduced to apply a pre-determined set of rules to an innovative technology. Rather, it has to be conceived as an occasion to enrich our moral knowledge.

Synthetic ethics does not exclude the traditional questions on which focus dichotomous approaches. Rather, it reframes them within a research perspective that views social robots as a means to empower our relationships. How can we build social robots that can work as social connectors, reinforcing human–human relationships, instead of producing isolation and weakening the social bond? How can we design social robots that facilitate, encourage and fortify exchanges among humans, instead of offering the possibility of escaping from the challenges of human–human interaction, and becoming estranged in an effortless world of human–robot interaction? Is it possible to exploit social robots to modify patterns of human behavior, in the direction of ethical growth? Such questions should be, and to some extent already are, part of the applied anthropomorphism of SR. Synthetic ethics is the approach in which these questions need to be raised at the level of the theoretical ideation, design, implementation, and experimental testing of social robots, rather than only addressed from the outside (and after the fact, so to speak) with a pre-established set of ethical rules.

The difference between a 'dichotomous' and a 'synthetic' approach to the ethics of SR should not be underestimated. The theoretical and epistemological choices we make in order to think, create, understand and regulate social robots will dramatically impact human–robot co-evolution – a mixed social ecology where ethical life may flourish.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication. The authors elaborated plan and contents of the article together. Each author is responsible for the final form of different parts of the article: Luisa Damiano for Introduction, Section 1 (Social Robotics as Applied Anthropomorphism) and Subsection 2 (Synthetic Ethics) of Section 3 (From 'Dichotomous Thinking' to 'Synthetic Ethics'); Paul Dumouchel for Abstract, Section 2 (Anthropomorphism and Social Coordination) and Subsection 1 (From Condemnation to Impotence) of Section 3 (From 'Dichotomous Thinking' to 'Synthetic Ethics').

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# Anthropomorphic Design: Emotional Perception for Deformable Object

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Despite the increasing number of studies on user experience (UX) and user interfaces (UI), few studies have examined emotional interaction between humans and deformable objects. In the current study, we investigated how the anthropomorphic design of a flexible display interacts with emotion. For 101 unique 3D images in which an object was bent at different axes, 281 participants were asked to report how strongly the object evoked five elemental emotions (e.g., happiness, disgust, anger, fear, and sadness) in an online survey. People rated the object's shape using three emotional categories: happiness, disgust–anger, and sadness–fear. It was also found that a combination of axis of bending (horizontal or diagonal axis) and convexity (bending convexly or concavely) predicted emotional valence, underpinning the anthropomorphic design of flexible displays. Our findings provide empirical evidence that axis of bending and convexity can be an important antecedent of emotional interaction with flexible objects, triggering at least three types of emotion in users.

**Keywords: anthropomorphism, emotional interaction, deformable object, human–computer interaction, user experience**

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## INTRODUCTION

Shapes are closely related to emotion. Takahashi (1995) researched pictorial perception, assessing person–object relations. According to the study, aesthetic characteristics, such as lines and textures, are related to the perceptual experience, interacting with expressive emotions, such as anger, happiness, serenity, disgust, sadness, and femininity. A study on shape has also been conducted, finding that shape evokes emotion in people. A certain shape can be linked with the adjectives that describe it; thus, a circular shape is related to the adjectives sad, clumsy, and passive while a triangular shape evokes a sharp and dangerous feeling. On the other hand, a quadrilateral shape induces a heavy and strong feeling in participants. Here, with the underlying precondition that shape plays a role in person–object relations, this paper assesses whether a shape anthropomorphizing human posture interacts significantly with emotion.

In recent decades, there has been an increasing number of studies on user experience (UX) and user interface (UI) for deformable displays. With "anthropomorphism" as the philosophy of design, it is necessary to implement emotional interaction between humans and deformable displays to provide positive implementation of UX. Anthropomorphism, assigning human characteristics such as emotion to a non-human object, enables users to be familiar with the deformable display since people unconsciously derive emotional stability from things that are similar to themselves. Herein, this paper examines which functions would be appropriate to implement on these personified flexible devices in a theoretical framework, particularly focusing on interaction between emotional input and output.

# LITERATURE REVIEW

## Anthropomorphism

According to research, people unconsciously tend to be attracted to things that are similar to themselves (Berger and Bradac, 1982). In the uncertainty reduction theory, familiarity plays a crucial role in relationship development both among humans and between humans and devices (Berger and Bradac, 1982). Indeed, Epley et al. (2007) argued that humanlike entities implement more familiar, explainable, or predictable qualities than do non-humanlike entities. According to Reeves and Nass' (1996) media equation theory, people tend to equate media (x) with real people (y) as if they were virtually experiencing real people or places. Thus, it is important to "give computers some personality" for the successful design of interactive technical products (Reeves and Nass, 1996).

Currently, anthropomorphism is extensively researched, particularly in the field of humanoid robots or human–robot interaction (HRI). Indeed, in the field of HRI, it has widely been found that anthropomorphized technologies, in the form of both humans and animal creatures, increase social interaction and support emotional bonding with humans (Li and Chignell, 2011; Yohanan and MacLean, 2012). For example, Softbank Robotics developed an emotionally interactive humanoid robot, Pepper, which identifies principal human emotions, changing mood, or behavior to interact with the users (Softbank Robotics, 2017). At the same time, iCub is another kind of humanoid robot that was developed at Istituto Italiano di Tecnologia. The iCub has its own sense of proprioception and movement as well as visual recognition capability developed via deep learning (The RobotCub Consortium, 2017) (see **Figure 1**).

Research on anthropomorphism in terms of interaction has not been limited to a humanlike appearance (Zlotowski et al., 2015). For instance, according to Kahn et al. (2006), six benchmarks elementary to humanlike interaction are autonomy, imitation, intrinsic moral value, moral accountability, privacy, and reciprocity. Turkle (2010) viewed behavior itself as the most crucial factor for anthropomorphic interaction with humans, and Wiese et al. (2017) recognized humanlike behavior as a critical factor underpinning social cognition in the human brain. Throughout this study, implementation of humanlike movement or behavior will be researched through usage of flexible displays.

At the same time, recent studies have attempted to evaluate a novel expression method applying principles of animation to technology. For example, Bates (1994) applied the animation theory "The Illusion of Life" (Thomas et al., 1995) developed by Walt Disney Animation Studios into the interactive agent. Likewise, van Breemen (2004) applied animation theory for the development of Lino and iCat, the UI robot. According to van Breemen (2004), development of emotionally interactive technologies is facing similar problems to those in the early stage of animation, contending that the principles of animation are applicable to interaction in robotics. For example, he viewed that easily recognizable poses enable users to easily identify actions. Other researchers have also employed or contrasted principles of classic animation, lifelike behavior of a character, with machine-like behavior of robots (Takayama et al., 2011; Ribeiro and Paiva, 2012; Saldien et al., 2014; Castro-González et al., 2016). However, this study focused on psychological means of bending a flexible display in terms of emotional interaction, eliminating other variables outlined by animation theory. This is because this study is exploratory research aiming to acquire new insights by finding phenomena common to all participants. Due to the characteristics of exploratory research, finding significant phenomena without explicit expectations (Schutt, 2011), there would be too many variables in animation theory to be covered in a single study. Therefore, it has been decided to limit the scope of the study to answer the question, "What emotion does the shape of an object provide to the user?" The result of the study itself can work as a framework for the researchers, designers, or manufacturers who explore the emotional interaction of flexible displays. Although the study focuses on a flexible display due to its familiarity, the results are applicable to the other kinds of objects with (1) rectangular shape, (2) distinguishable front and backside, and (3) technically deformable features.

## Flexible Devices

Flexible display, first conceptualized and prototyped by Xerox PARC (Palo Alto Research Company) in 1974, refers to a dynamic display that can be forced out of shape. Display-related companies, such as Nokia (Nokia Morph concept, 2008), Sony (OTFT-Driven OLED display, 2010), Samsung (Youm, 2013), and LG (OLED flexible display, 2013), have developed flexible displays (Noda et al., 2011; Mathur et al., 2013; Mone, 2013; Shao et al., 2015). Leading display manufactures registered patents on flexible displays, such as foldable and bendable displays, for portable devices (Rothkopf et al., 2014; Bae et al., 2018). These products are expected to permeate our lives, but, before we introduce these technologies, it is necessary to find the emotional value of such products.

There are two types of displays called flexible displays. The first is rigid and fixed in shape. Examples of this flexible display include the LG curved phone and Samsung Edge, which have glass material that works as a lower board and protects the display. The second type of flexible display is a dynamic display, which has an innovative form factor such that it can flexibly change its shape. For example, Samsung officially launched their flexible OLED display, called the Youm display, which was demonstrated at CES 2013 (Samsung, 2013). According to previous studies, these technologically available flexible displays have potential to trigger emotional interaction, enhancing usability (Lee et al., 2015; Strohmeier et al., 2016). Using anthropomorphism as a philosophy of design, this paper investigates the variables that convey emotional value to users by taking flexible display as a research domain.

### UX Trend for Flexible Devices

Beyond stiff and brittle displays, there has been increasing research aiming to optimize UX and UI for flexible displays. Rendl et al. (2014) presented FlexSense, a thin, transparent, deformable surface. Through FlexSense, they proposed that a surface with a deformable display comprised a performative UI, providing a high degree of freedom in input control and applicable in various scenarios such as Photoshop, online maps,

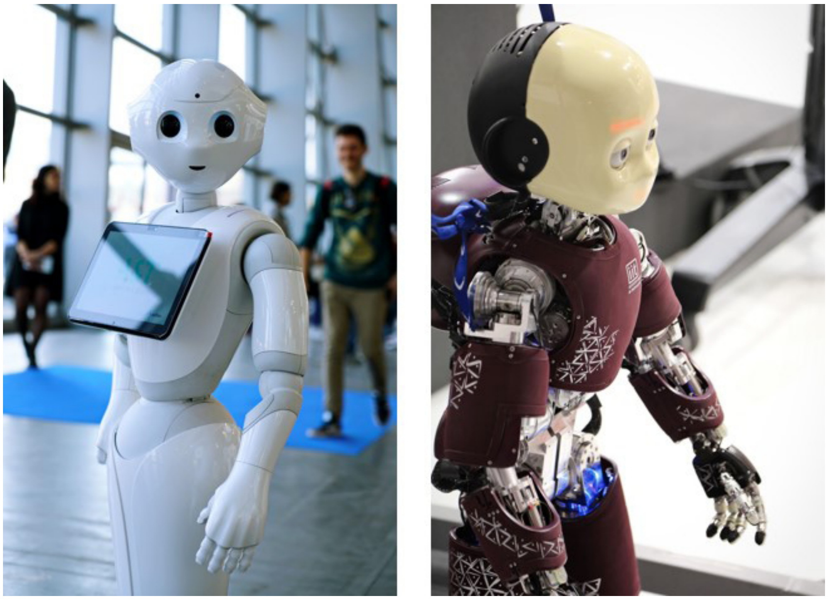

**FIGURE 1 |** Anthropomorphism in robotics. Pepper (Left) and iCub (Right). Images, used under license from MikeDotta/Shutterstock.com.

games, and education. Ahmaniemi et al. (2014) also proposed different methods of bending on a deformable display: zooming, image editing, reading, map information, navigation, browsing large amounts of information, quick reactions, and games. They argued that a dynamic control could be implemented on a flexible display that even requires high resolution.

Interaction methods of flexible displays have also been widely researched in recent years. Lee et al. (2010) examined the interaction method of flexible displays, such as bending, folding, and stretching, derived from plastic, paper, and elastic cloth. Likewise, Gomes et al. (2013) and Hemmert et al. (2013) researched possible interaction methods that could be applicable to future flexible devices. Warren et al. (2013), on the other hand, researched the bending interaction itself. They collected 36 bending gestures and investigated the preferred location and direction in which participants interacted. The UI of devices was also expected to be altered if the display became flexible in the future. Through FoldMe, Khalilbeigi et al. (2012) studied possible design spaces for a double-sided foldable display. Apart from finding possible ways to fold the displays, the authors designated possible UIs for the double-sided foldable display, indicating that it would be efficient for foldable multitasking, tool palettes, layers, and spin control.

## Emotional Interaction of Flexible Devices

According to Triberti et al. (2017), technology designers should consider the emotional factors that align with users' everyday lives, and these emotionally interactive technological products enhance loyalty and satisfaction and may promote happiness and well-being. Kwon and Ju (2018) also indicated that emotional experience of the customers, such as familiarity and comfort, should be considered for the customer centric design. Dawson et al. (2013) have studied the emotional interaction of deformable displays, finding that the flexible display provides simple but powerful gestural implications such as breathing, curling, crawling, ears, and vibration. Likewise, their study examined the emotional interaction of flexible displays but focused on the influence of complexity, direction (alignment), and convexity on emotional interaction for users. Through Bendi, a device that changes its upper and/or lower section, Park et al. (2015) indicated that the shape-changing device could be actively used to share emotions among users, facilitating both visual and tactile interaction. Their study also found that flexible devices enhance emotional communication between users. Moreover, Bailenson et al. (2007) investigated the emotional interaction between humans and tactile devices, although their study concentrated on tactile interaction with a virtual hand instead of flexible display interaction. Strohmeier et al. (2016) and Lee et al. (2015) also supported the existence of the emotional interaction of flexible displays through the Circumplex Model of Emotion developed by Russell (1980). The pattern, which implicates the sharing of emotion, was observed in each quadrant of the model.

Indeed, according to Lee et al. (2017), people tend to perceive flexible devices as humanlike, seeing the top as the head, the middle as the waist, and the lower part as the knees. When corner-bending was implemented, there was a tendency for participants to see the bending of the top corners as human arms and the bending of the bottom corners as legs. This result aligned with emotional studies that recognized the role of body language in expressing emotions (Atkinson et al., 2004; Clarke et al., 2005). Since previous studies were qualitative and particularly concentrated on the existence of emotional interaction instead of on humanlike bending, this study aims to find the standard tendency of participants regarding how they project humanlike bending on flexible displays.

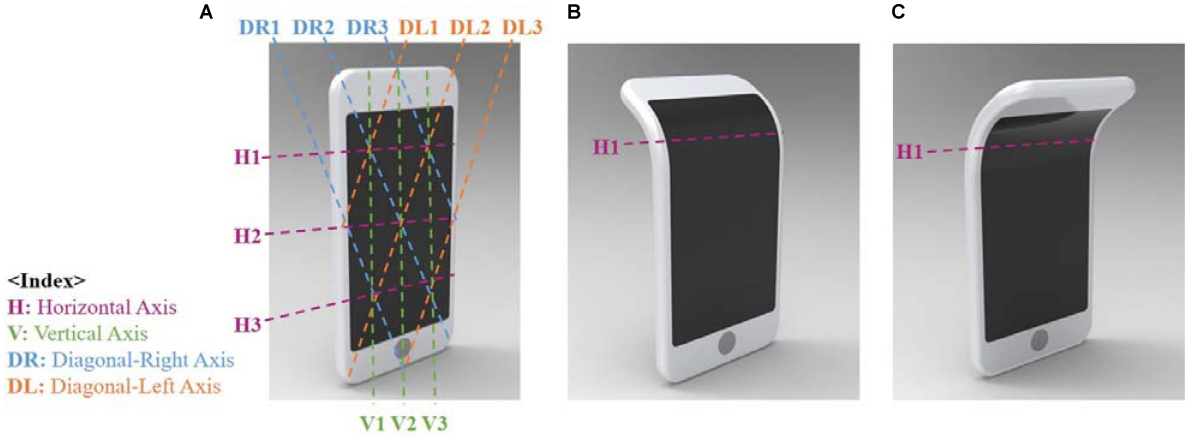


**FIGURE 2 |** Shapes were made up of bends in three horizontal (H1, H2, H3), three vertical (V1, V2, V3), three diagonal right (DR1, DR2, DR3), and three diagonal left axes (DL1, DL2, DL3). **(A)** An example of flat shape (no bending), **(B)** an example of concave bending at a horizontal axis, **(C)** an example of convex bending at a horizontal axis.

### Emotion Model and Flexible Devices

Extensive research has been conducted on the classification of emotion using facial expression and body shape (Darwin, 1872/1965; James, 1890; Ekman, 1965; Frijda, 1988; Jellema and Perrett, 2003; Atkinson et al., 2004; Clarke et al., 2005; Chouchourelou et al., 2006). Among various emotional models, Paul Ekman's six basic emotions have been used extensively in research studies. According to Ekman (1999), there are six elementary emotions in terms of facial expression: happiness, sadness, anger, fear, disgust, and surprise. However, there are controversies regarding defining the elementary emotions into six groups with reports that it is difficult to either recognize particular emotions or replicate the study's results. Indeed, Baron-Cohen et al. (1993) reported that the emotion "surprise" was not found in their study, and Oatley and Johnson-Laird (1987) found that surprise is amendable to cultural influences. Meanwhile, studies investigating expressions of emotions based on Ekman's six basic emotions revealed confusion in discriminating surprise from other emotions. Particularly, a number of studies found surprise to be confused with fear (Calvo and Lundqvist, 2008; Tottenham et al., 2009; Recio et al., 2013; Jack et al., 2014). For instance, Jack et al. (2014), who researched dynamic expression of emotions, revealed that surprise is close to the emotion of fear. According to them, rather than being a "basic emotion," surprise is a response, a reaction to something that has been unexpected. Herein, among Paul Ekman's six basic emotions, only five were used to conduct the survey with surprise withdrawn from the list.

## MATERIALS AND METHODS

In the current study, we used an online survey to investigate 281 users' emotional evaluations regarding various shapes of an imaginary flexible device. The shape changes included folding, bending, rolling, pinching, zero-crossing, twisting, and crumpling. To generate these shapes, we computed all combinations of 60° bends in three horizontal, three vertical, three diagonal right, and three diagonal left axes (see **Figure 2**). For each axis, the device had one of three convexities: concave (bending forward), convex (bending backward), or flat (no bending). Strictly speaking, convex shape is often interpreted as either biconvex (both sides being curved outward) or plano-convex (single side being curved outward while the other side remains flat) while concave is interpreted as biconcave (both sides being curved inward) or plano-concave (single side being curved inward while the other side remains flat). However, as in Strohmeier et al. (2016), the convex shape in this study was a converging meniscus shape where the front side of the face curved outward while the opposite side of the face curved inward. Contrarily, the concave shape was a diverging meniscus shape where the front part of the face curved inward while the opposite face curved outward.

To eliminate redundancy in combinations ($3^{12}$ = 531,441 shapes), the max number of bendings was three for 2049 shapes. Then, technically impossible shapes were discarded. These shapes included (1) shapes bent on both vertical and horizontal axes without diagonal bendings, (2) shapes bent on either vertical or horizontal axes as well as on diagonal axes, and (3) shapes bent on any diagonal-right axes as well as on the middle diagonal-left axis and vice versa. After eliminating technically impossible shapes, 153 shapes remained. Finally, vertically mirrored duplicates – 52 shapes – were again eliminated. As a result, 101 unique shapes were generated. All data and materials are publicly available on the project page in the Open Science Framework[1].

### 3D Modeling

These 101 possible 3D images of flexible displays were created using 3D Rhino. All the flexible displays featured an iPhone that was 67 mm × 138 mm × 7 mm. To remove the ambiguity that often occurs with a single viewpoint, each shape

[1] https://osf.io/bruvk

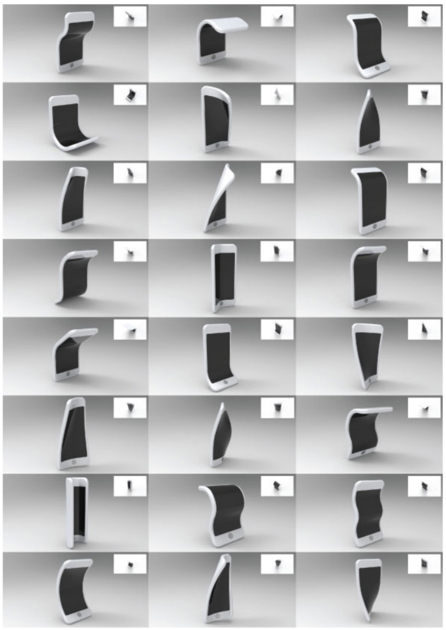

**FIGURE 3 |** Examples of 3D modeled images. The main images of the shapes are positioned in the center, and the supplemental images of the shapes are placed at the top right corner.

was rendered in two viewpoints – "distance = 266.12 mm, azimuth = −50°, Inclination = 15°" and "distance = 266.12 mm, azimuth = −132.53°, inclination = 53.22" – with the former as a main image positioned in the center and the latter as an additional image placed at the top right corner of the former (see **Figure 3**).

## Procedure and Measurements

A quantitative online survey was conducted for this study. After a short questionnaire for demographic information, all participants completed five blocks of emotional evaluation. In each block, 101 shapes were evaluated in terms of the targeted emotion: happiness, sadness, anger, disgust, and fear. For example, participants were asked to answer, "How much does the object look ANGRY?" for each of the 101 shapes in the first block, "How much does the object look HAPPY?" for the same shapes again in the second block, and so on. Participants responded by selecting a choice on a seven-point Likert-type scale (1 = not at all, 7 = very strongly). The block order was shuffled across participants, and shapes were presented in a random order in each block. The survey session took approximately 60–90 min. This study was carried out in accordance with the recommendations of the Institutional Review Board at Yonsei University. The protocol was approved by the Yonsei University Institutional Review Board. All participants, aged 18 and above, gave written informed consent in accordance with the Declaration of Helsinki. Participants received $10 in compensation for their participation and could quit anytime during the survey if they did not want to continue. No personal identifying information was collected.

**TABLE 1 |** Demographics of survey participants.

| Age | Gender | | Total (%) |
|---|---|---|---|
| | Male (%) | Female (%) | |
| 10s | 27 (9.09) | 34 (11.45) | 61 (20.54) |
| 20s | 30 (10.10) | 27 (9.09) | 57 (19.19) |
| 30s | 25 (8.42) | 30 (10.10) | 55 (18.52) |
| 40s | 26 (8.75) | 31 (10.44) | 57 (19.19) |
| 50s and above | 30 (10.10) | 37 (12.46) | 67 (22.56) |
| Total | 138 (46.5) | 159 (53.5) | 297 (100) |

# RESULTS

## Participants

A total of 368 participants volunteered to participate in the study. To obtain data from the general population, we attempted to assign an equal quota across age groups and gender. None of the age–gender groups exceeded 10 ± 2.5% (see **Table 1**). Low reliability has often been pointed out as one of the major limitations of a web-based survey. To avoid this issue, we excluded outliers with three criteria. First, each emotion block included five checksum questions: five shapes were asked twice, randomly interleaved with the other 101 shapes for each emotion block. Participants were excluded if they gave different responses to the same question on two occasions (root mean squared error for 25 checksum questions was greater than 2.0). The first criterion detected 17 outliers. The second criterion was the max frequency in each block. Some participants could habitually give the same response for the most questions. Such outliers were detected by the max frequency; if a participant's max frequency was greater than or equal to 101 (out of 106 questions including the checksum questions) in any emotional block (e.g., responding 3-3-3-3-3-... repeatedly 101 or more times), the participant was excluded. This criterion detected 25 outliers. With the second criterion, we could fail to find outliers who regularly changed answers (e.g., responding 3-4-3-4-3-4... repeatedly). To exclude these outliers, we also computed a standard deviation over 530 answers (106 answers × 5 emotional blocks) for each participant. If a participant's SD was less than 1.0, we regarded the participant as an outlier. Following this rule, there were 58 outliers. In total, 87 outliers were detected and excluded in the following data analysis. Please note that some outliers belonged to two or more criteria. Responses for the checksum questions were also discarded in the analysis. Therefore, 101 responses for each block from the remaining 281 participants were analyzed in this study.

## Correlation Analysis for Each Emotion

Although five elementary emotions on human facial expression have been identified (Ekman, 1999), little is known about the evaluation for the emotion of an object. To figure out the elementary emotions attributed to the flexible device, we tested correlations between the average scores (over 281 participants) for 101 images for two different emotions. As shown in **Table 2**, all emotional categories were significantly correlated except for between happy and anger. As expected, happiness showed

**TABLE 2** | Correlation analysis of the emotions.

| | Happiness | Sadness | Fear | Anger | Disgust |
|---|---|---|---|---|---|
| Happiness | 1.000 | −0.256** | −0.271** | −0.184 | −0.274* |
| Sadness | | 1.000 | 0.954*** | 0.436*** | 0.659*** |
| Fear | | | 1.000 | 0.554*** | 0.773*** |
| Anger | | | | 1.000 | 0.904*** |
| Disgust | | | | | 1.000 |

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

significantly negative correlations with sadness ($r = -0.256$, $p = 0.010$), fear ($r = -0.271$, $p = 0.006$), and disgust ($r = -0.274$, $p = 0.006$) but a marginally significant negative correlation with anger ($r = -0.184$, $p = 0.065$). Among correlations between four negative emotions, sadness–fear ($r = 0.954$, $p < 0.001$) and anger–disgust ($r = 0.904$, $p < 0.001$) showed strong correlations.

To further investigate the relation between negative emotions, we tested the significance of the difference between correlation coefficients. As results, sadness had significantly greater correlation with fear than with anger ($z = 9.85$, $p < 0.001$) or disgust ($z = 7.58$, $p < 0.001$). Fear also had significantly greater correlation with sadness than with anger ($z = 8.75$, $p < 0.001$) or disgust ($z = 5.93$, $p < 0.001$). That is, correlation between sadness and fear was significantly stronger than any other correlations involving sadness and fear. Likewise, anger had significantly greater correlation with disgust than with sadness ($z = 7.18$, $p < 0.001$) or fear ($z = 6.09$, $p < 0.001$). Disgust also had significantly greater correlation with anger than with sadness ($z = 4.92$, $p < 0.001$) or fear ($z = 3.26$, $p = 0.001$). These results suggest that correlation between anger and disgust was significantly stronger than any other correlations involving anger and disgust.

To summarize, in contrast to the five emotions for facial expressions, participants perceived shapes of a flexible device as exhibiting three groups of emotions: (1) happiness, (2) sadness–fear, and (3) anger–disgust. In the following analysis, therefore, we will use three emotional categories. The sadness–fear score was calculated by averaging each participant's sadness and fear ratings for each shape. Ratings for anger and disgust were also collapsed to produce the anger–disgust score.

## Pattern of Emotional Interaction

To explore which shapes evoked strong emotional responses, we first selected shapes with an average rating higher than the mean + 1 SD of 101 rating scores (averaged across all 281 participants) for each emotional category. With criteria of 3.585 (=3.317 + 0.26), 3.992 (=3.537 + 0.455), and 4.000 (=3.650 + 0.350), a total of 12, 11, and 15 shapes were selected for happiness, sadness–fear, and anger–disgust, respectively. As clearly shown in **Figure 4**, only a few shapes evoked high emotional responses in two categories, and none did in all three categories.

### Happiness

All high-happiness shapes had bendings on horizontal axes (mainly convex); none had a bending on vertical or diagonal axis. To further identify common factors of these shapes, we conducted an exploratory factor analysis with varimax rotation ($n = 281$). Results suggested there were two factors whose eigenvalues were greater than 1.0 (eigenvalue for factor 1 = 6.024; eigenvalue for factor 2 = 1.294), accounting for 60.984% of the total variance. Factor loadings of highly happy shapes and their physical properties are summarized in **Table 3**, and images for shapes are shown in **Figure 5**. The table and figure clearly show the unique property of the first factor: a convex bending on horizontal axes. All these shapes had one or two convex bending(s) at the middle or the top horizontal axis, reminding us a laughing figure. The second factor was made up of combinations of convex and concave bendings on horizontal axes in a sandwiched manner (e.g., concave-convex-concave) with either a simple (#46 and #48 with two bendings) or a complex shape (#80 or #87 with three bendings). These shapes reminded us a giggling figure.

### Sadness–Fear

There were 11 shapes that participants rated highly sad and fearful. Except for shape #82, all highly sad–fearful shapes had bendings on horizontal axes (mainly concave); none had a bending on vertical or diagonal axis.

We submitted all shapes to an exploratory factor analysis with varimax rotation ($n = 281$). Results suggested a two-factor solution (eigenvalue for factor 1 = 7.052, eigenvalue for factor 2 = 1.011), explaining 73.307% of the total variance. Factor loadings of highly sad and fearful shapes and their physical properties are summarized in **Table 4**, and images for shapes are shown in **Figure 6**.

The table and figure show the unique property of the first factor: a concave bending on horizontal axes. In contrast to happiness, sadness and fear was evoked by shapes that were bent in a concave manner at either the middle or the top horizontal axis or both. These shapes looked like a figure inclining its head. Shape #82 was an exception to this common property of the first factor. All of its vertical axes were bent concavely, resembling a figure inclining or shrinking inward.

Just like the second factor of highly happy shapes, the second factor of highly sad and fearful shapes is made up of combinations of concave and convex bendings on horizontal axes in complex shapes (three bendings). Indeed, shapes #80 and #87 evoked high happiness as well as high sad–fearful. These belonged to the second factors of both highly happy and highly sad and fearful shapes. It seemed that the common shapes and their properties (i.e., a combination of concave and convex bendings in a sandwiched manner with a complex shape) were perceived sometimes as giggling figures and sometimes as trembling figures.

### Anger–Disgust

There were 15 shapes that participants rated highly angry and disgusting. In contrast to happy and sad–fearful emotional shapes, which had bendings on horizontal axes but no diagonal axis, all highly angry and disgusting shapes, except for #82, bendings on diagonal axes and no horizontal axis (neither concave nor convex). No emotional response was evoked by bending on vertical axis in any of the three emotional categories.

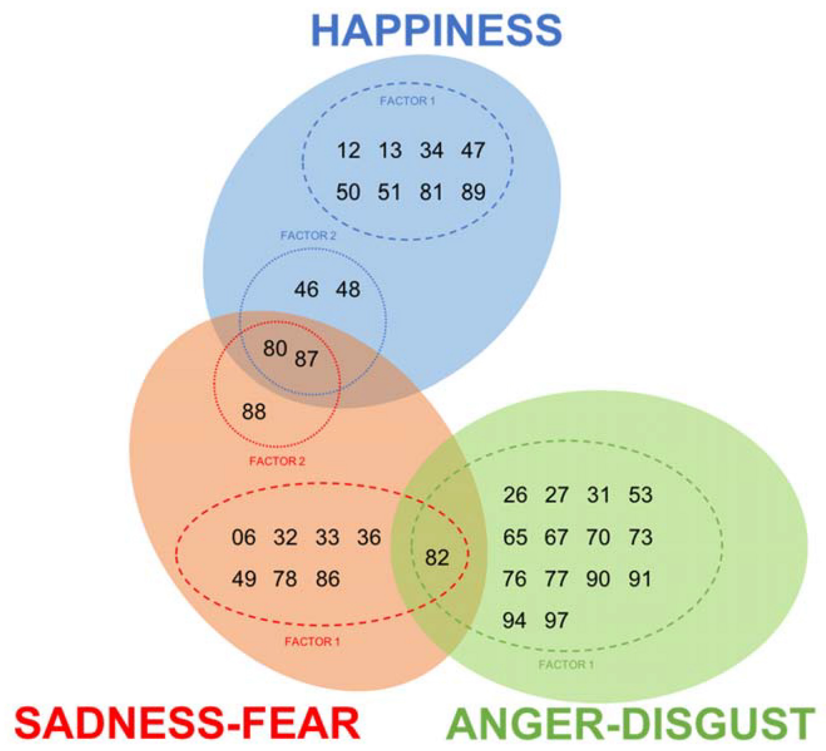


**FIGURE 4 |** Highly emotional shapes for each emotional category. Numbers in the Venn diagram represent the image ID number. A total of 12, 11, and 15 shapes were selected for happy (blue circle), sad–fearful (red circle), and angry–disgusted (green circle), respectively. Only a few shapes evoked high emotional responses in two categories, and none did in all three categories. Dashed circles show factors in each emotional category. (See texts in the next section for more details).

**TABLE 3 |** Factor loadings of 12 high-happiness shapes along with physical properties.

| Shape ID | Factor 1 | Factor 2 | Bending | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | V1 | V2 | V3 | H1 | H2 | H3 | DR1 | DR2 | DR3 | DL1 | DL2 | DL3 |
| 51 | 0.783 | | – | – | – | – | −1 | −1 | – | – | – | – | – | – |
| 47 | 0.749 | | – | – | – | −1 | −1 | – | – | – | – | – | – | – |
| 12 | 0.717 | | – | – | – | −1 | – | – | – | – | – | – | – | – |
| 50 | 0.715 | | – | – | – | −1 | – | −1 | – | – | – | – | – | – |
| 89 | 0.705 | | – | – | – | −1 | −1 | −1 | – | – | – | – | – | – |
| 13 | 0.702 | | – | – | – | – | −1 | – | – | – | – | – | – | – |
| 81 | 0.602 | 0.546 | – | – | – | −1 | −1 | 1 | – | – | – | – | – | – |
| 34 | 0.524 | | – | – | – | −1 | – | 1 | – | – | – | – | – | – |
| 80 | | 0.844 | – | – | – | 1 | −1 | 1 | – | – | – | – | – | – |
| 87 | | 0.836 | – | – | – | −1 | 1 | −1 | – | – | – | – | – | – |
| 46 | | 0.655 | – | – | – | 1 | −1 | – | – | – | – | – | – | – |
| 48 | | 0.640 | – | – | – | – | 1 | −1 | – | – | – | – | – | – |

*Factor loadings with absolute values less than 0.50 have been suppressed. Bending columns show convexity of bending on 12 possible lines (1 = concave; −1 = convex; dash = no bending).*

We also conducted an exploratory factor analysis ($n$ = 281) for high-anger–disgust shapes. Results showed that only the first factor had a dominant eigenvalue (eigenvalue for factor 1 = 9.283) compared to the remaining factors (eigenvalues for other factors <1.0). The first factor accounted for 61.885% of the total variance. Physical properties of high-anger–disgust shapes are summarized in **Table 5**, and images for shapes are shown in **Figure 7**.

The table and figure show the unique property of high-anger–disgust shapes: bendings on diagonal axes. Except for shape #82, all these shapes had at least two bendings on diagonal axes. More specifically, they were always bent at the axes connected to the top edge of object (i.e., DL1, DL2, DR1, or DR2) at least once. Such a common property hinted to us that

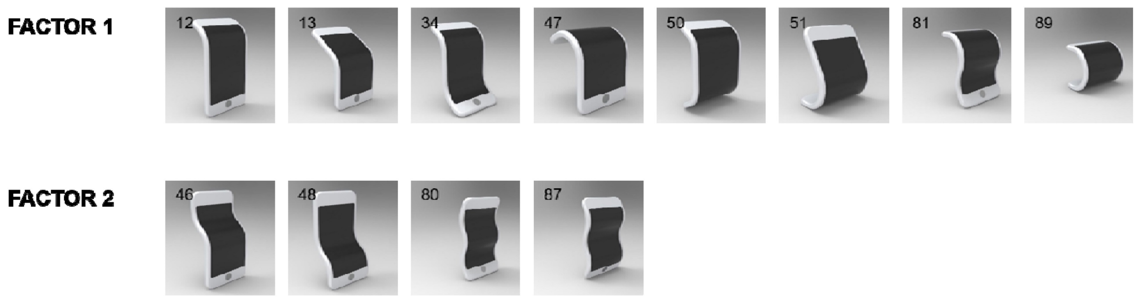


**FIGURE 5 |** Shapes evoking happiness. All these shapes had bendings on horizontal axes (mainly convex) but not vertical or diagonal axis. Exploratory factor analysis suggested two factors for happiness. Numbers in the upper-left corner of images represent the shape ID numbers.

**TABLE 4 |** Factor loadings of 11 high-sadness–fear shapes along with physical properties.

| Shape ID | Factor 1 | Factor 2 | Bending | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | V1 | V2 | V3 | H1 | H2 | H3 | DR1 | DR2 | DR3 | DL1 | DL2 | DL3 |
| 36 | 0.863 | | – | – | – | 1 | 1 | – | – | – | – | – | – | – |
| 32 | 0.849 | | – | – | – | – | 1 | 1 | – | – | – | – | – | – |
| 78 | 0.804 | | – | – | – | 1 | 1 | 1 | – | – | – | – | – | – |
| 6 | 0.779 | | – | – | – | – | 1 | – | – | – | – | – | – | – |
| 33 | 0.696 | | – | – | – | 1 | – | 1 | – | – | – | – | – | – |
| 49 | 0.694 | | – | – | – | 1 | – | –1 | – | – | – | – | – | – |
| 86 | 0.681 | 0.559 | – | – | – | 1 | 1 | –1 | – | – | – | – | – | – |
| 82 | 0.669 | | 1 | 1 | 1 | – | – | – | – | – | – | – | – | – |
| 87 | | 0.885 | – | – | – | –1 | 1 | –1 | – | – | – | – | – | – |
| 80 | | 0.866 | – | – | – | 1 | –1 | 1 | – | – | – | – | – | – |
| 88 | | 0.596 | – | – | – | 1 | –1 | –1 | – | – | – | – | – | – |

*Factor loadings with absolute values less than 0.50 have been suppressed. Bending column shows convexity of bendings on 12 possible lines (1 = concave; –1 = convex; dash = no bending).*

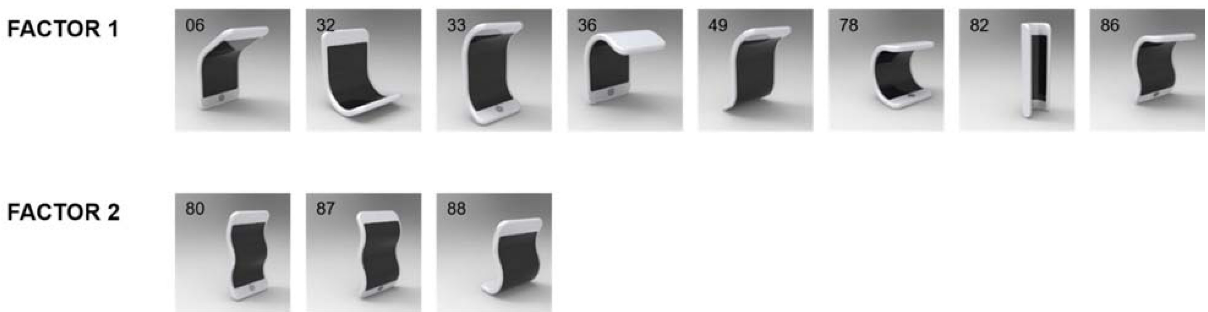


**FIGURE 6 |** Shapes evoking sadness–fear. Except #82, all shapes had bendings on horizontal axes (mainly concave), but not a vertical or diagonal axis. Exploratory factor analysis suggested two factors for sadness–fear. Numbers in the upper-left corner of images represent the shape ID numbers.

participants perceived these shapes as a figure twisting its shoulder.

Shape #82 was again an exception for this property. As shown in **Figure 4**, #82 belonged to high-anger–disgust shapes as well as high-sadness–fear shapes. It seemed that #82's shape of shrinking its shoulder or body was often perceived as suggesting all negative emotional states.

# DISCUSSION

## Categories of Emotion

In a series of studies, Ekman found that people – regardless of cultural background – categorized human facial expressions into five categories. In contrast, our study showed that people categorized objects' shapes into three categories. Participants could not discriminate disgust from anger nor sadness from fear

**TABLE 5 |** Physical properties of 15 high-anger–disgust objects.

| Shape ID | Bending | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V1 | V2 | V3 | H1 | H2 | H3 | DR1 | DR2 | DR3 | DL1 | DL2 | DL3 |
| 26 | – | – | – | – | – | – | – | – | – | 1 | 1 | – |
| 27 | – | – | – | – | – | – | – | – | – | –1 | 1 | – |
| 31 | – | – | – | – | – | – | – | –1 | 1 | – | – | – |
| 53 | – | – | – | – | – | – | – | –1 | –1 | – | – | – |
| 65 | – | – | – | – | – | – | – | – | – | – | –1 | –1 |
| 67 | – | – | – | – | – | – | – | – | – | –1 | 1 | 1 |
| 70 | – | – | – | – | – | – | – | – | –1 | 1 | – | 1 |
| 73 | – | – | – | – | – | – | – | – | 1 | –1 | – | 1 |
| 76 | – | – | – | – | – | – | – | – | – | 1 | –1 | 1 |
| 77 | – | – | – | – | – | – | – | – | – | –1 | –1 | 1 |
| 82 | 1 | 1 | 1 | – | – | – | – | – | – | – | – | – |
| 90 | – | – | – | – | – | – | – | – | – | 1 | 1 | –1 |
| 94 | – | – | – | – | – | – | – | – | –1 | 1 | – | –1 |
| 97 | – | – | – | – | – | – | – | – | 1 | –1 | – | –1 |
| 26 | – | – | – | – | – | – | – | – | – | 1 | 1 | – |

*Bending columns show convexity of bendings on 12 possible lines (1 = concave; –1 = convex; dash = no bending).*


**FIGURE 7 |** Shapes evoking anger–disgust. Except for shape #82, all shapes had bendings on diagonal axes but not vertical or horizontal axis. Exploratory factor analysis suggested there is a single factor for anger–disgust. Numbers in the upper-left corner of images represent the shape ID numbers.

in our study. In some sense, it seems to be natural for sadness to be grouped with fear and anger with disgust. This is because, by nature, sadness and fear are directed inward (inside oneself) while anger and disgust are directed outward (toward an object outside of oneself).

High correlation between disgust and anger was commonly found in previous literature exploring recognition of emotions (Palermo and Coltheart, 2004; Tottenham et al., 2009; Recio et al., 2013). However, correlation between sadness and fear was not frequently reported. It is not clear why our participants did not show differences between two emotions. One possibility could relate to the precision of emotional expression. Facial expressions are made from combinations of 28 or more action units (facial muscles) with variable intensities, but our objects were generated with combinations of only eight units, each with a fixed intensity of bending. Another possible explanation is that participants perceived stimuli as postures rather than facial expressions. As Ekman pointed out, people are more sensitive to facial expressions than to the emotional value of postures. Future investigation will be required to clarify this issue.

## Relation Between Bending and Emotional Interaction

In the field of robotics, the cognitive underpinnings of emotional interaction between human and anthropomorphized robotics is considered crucial since robots have "synthetic psychology," a state of not possessing internal emotion regardless of external emotional expression (Damiano and Dumouchel, 2018). That is, this new kind of synthetic interaction between human and anthropomorphized technology should be explored for the derivation of the emotionally interactive technologies considered necessary for social (Schmitz, 2011; Riether et al., 2012; Kwak, 2014) functionality, which enhance familiarity (Choi and Kim, 2009), likability (Castro-González et al., 2016), and encouragement (Breazeal, 2006).

This study found that the shape of the bended flexible display indicates a certain emotional expression, confirming the hypothesis that the anthropomorphic design of the flexible display would enable emotional interaction with the users. Since it is necessary to anthropomorphize the display using a simplistic pattern in the early stage of technical development, certain patterns that indicate emotion to users needed to be investigated.

Here, based on the parameters that may underpin the emotional interaction of the flexible display, the axis of the bending and convexity of the curve were researched thoroughly. Through this empirical study, which examined how much the 3D-modeled image of a flexible display represents specific emotions to the participants, certain patterns have been found regarding the axis of bending and convexity. In terms of individual emotions, first, happiness was represented by the combination of a convexly curved display that has bendings on horizontal axes, significantly distinguishing itself from the other four emotions. Sadness and fear, which were highly correlated, had a concavely curved display that has bendings on horizontal axes. Last, anger and disgust, which also correlated with each other, had a curved display that has bendings on diagonal axes regardless of bending convexities.

Broadly, taking the conventional recognition concept that happiness conveys positive emotion while the other basic expressions, sadness, anger, fear, and disgust, are negative, it can be said that convex shape triggered positive emotion while concave shape conveyed negative emotion to the participants. This perception can be analyzed via Russell's Circumplex model (Russell, 1980) since emotion space representation can be well presented through a plane defined by two dimensions. One of the indicators of this plane is the level of arousal while the other is the level of valence. Aligning with Jeong and Suk (2016), the result recognized the positivity and negativity of the valence on categorization of emotion. It was found that happiness, on the pleasant plane, has convex bending in a horizontal axes while other unpleasant emotions on the negative plane, anger, sadness, disgusted, and fear, have convex bending.

From this perspective, there is concern over misinterpretation of emotion expression since, regardless of subdivision of emotion group into categories, there are numerous ambiguous emotions. Indeed, according to Jack et al. (2014), it is necessary to find rules that trigger specific emotion since misinterpretation of emotional expression may impose negative UX to users, conveying social rejection to the user. Herein, it is necessary to find unique emotion since it reduces the chance of misinterpretation, demonstrating the necessity of future work to find other factors that influence clearer discrimination of emotional expression of flexible display in users.

The results in which the participants portrayed their emotional value on a flexible display align with the research conducted by Pedersen et al. (2014), Lee and Ju (2015), and Strohmeier et al. (2016), who investigated the emotional interaction of shape-changing displays. However, contrasting with Strohmeier et al. (2016), which found that bending on horizontal axis was the strongest predictor of the level of valence in the emotion, this research also highlights the significance of the curvature that bends on a diagonal axis, particularly when it conveys the emotions of anger and disgust.

## Parameters Underpinning Anthropomorphic Design of Flexible Displays

Our findings suggested some basic parameters required for anthropomorphic design of an emotional object. First, bending in horizontal and diagonal axes should be available. Bending along the horizontal axis should be applicable to express happiness, sadness, and fear while bending along a diagonal axis would express anger and disgust. Interestingly, bending along the vertical axis was not a critical factor for triggering emotional interaction in the users. Second, both concave and convex bending should be feasible. The results revealed that convex bending is required to express happiness, concave bending for sadness and fear, and both concave and convex for anger and disgust.

## Research Implications

In our study, we explored the object characteristics that reflect specific emotion. This study provides insight for understanding the emotional interaction between a human and an anthropomorphic object. It has been empirically shown that there exists emotional interaction between human and flexible displays, and three emotional categories for anthropomorphic flexible display have been suggested (Lee et al., 2015; Strohmeier et al., 2016). In this paper, we suggest a systematic method for studying emotional interaction between a human and an anthropomorphic object.

Flexible displays have enormous potential, and many believe that they will be commercially viable in the near future. However, studies of the anthropomorphic design of flexible displays and their user interaction remain scarce. Our study aimed to provide significant information to researchers and designers who intend to develop emotionally interactive devices or designs.

## Limitations of the Current Study

Although we successfully found factors influencing emotional interaction between humans and flexible objects, this study has a few limitations. First, the study was conducted with participants from a single cultural background. Ekman (1999) found that emotional perception was cross-cultural for facial expression. However, little is known of the effects of cultural difference on emotional perception for anthropomorphic objects. Therefore, to generalize our results, a cross-cultural study should be conducted with the same research framework as ours. Second, the study was carried out with only 101 static shapes, which were systemically made of combinations of 12 axes of bending. However, these shapes were not a comprehensive set of the postures possible for an object. For example, one might imagine thousands of other shapes by considering the angle of bending (e.g., 0, 30, 60, and 90°). It was technically difficult to collect data for all these shapes in a single study, but there could be various variables worthy of examination. For the same reason, we limited the scope of the current study to static objects. One could easily think that emotional interaction might be affected by a number of variables regarding movements such as speed, angle, amplitude, radius, and area in motion. The principles of animation could also be adopted, conducting more in-depth evaluation on shapes that evoke emotions by focusing on shapes that were built from the previous studies. These should be investigated in future studies.

## AUTHOR CONTRIBUTIONS

JML, JB, and DYJ conceived, designed, and conducted the study. All authors wrote, reviewed, and edited the manuscript.

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