What behaviours lead children to anthropomorphise robots?

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Abstract. Anthropomorphism is the attribution of human-like thoughts and feelings to a non-human entity, typically animals, toys or technological devices. Adults readily anthropomorphise even simple geometric shapes with no personifying features, evidence that anthropomorphism is elicited by the way an object behaves as much as the way that it looks. Recent regulatory concerns with regards user-confusion has led many robot designers to seek out non-humanoid robot forms, yet relatively little research is exploring how robot behaviours in the absence of personifying features may be both helpful and unhelpful for appropriate user engagement. Key to understanding what factors contribute to robot-anthropomorphism is a better understanding of its foundations in human thought. Current models of the development of anthropomorphism are outdated and fail to capture the interaction between perceiver and perceived. Here we review the relevant literature on the development of anthropomorphism as a psychological bias in children. We propose a new programme of research to expose the key behavioural drivers of anthropomorphism and examine their effectiveness for children of different ages.

1 INTRODUCTION

Rule 4 of the Principals of robotics [1] states that 'Robots are manufactured artefacts. They should not be designed in a deceptive way to exploit vulnerable users; instead, their machine nature should be transparent.' Key to concerns about exploitation is the knowledge that anthropomorphism: attribution of human-like thoughts and feelings to non-human entities, is a common and unavoidable feature of human-robot interaction [2, 3]. This psychological bias is exacerbated if the robot has human-like features [4, 5, 6] and so regulatory bodies are considering the advantages of a move away from humanoid robots with faces and human-like body-parts towards more zoomorphic or mechanomorphic forms. For example, the IEEE Ethically Aligned Design initiative [7] has a standards committee (P7001) actively working on standards for Transparency of Autonomous Systems, including considerations to avoid anthropomorphic misunderstanding of robots. However, anthropomorphism is not triggered by appearance alone. Adults readily anthropomorphise even simple geometric shapes with no personifying features [8, 9, 10, 11]. Critical to anthropomorphism are behaviours [12] which we define here as actions such as speed of motion [13], orientation [12, 13, 14, 15] and unpredictable responses [16]. Although robot behaviour is potentially a much stronger trigger of anthropomorphism than appearance, relatively little research is examining how robot behaviours might be deliberately manipulated to increase or decrease user anthropomorphism. Children are one of the key target markets for robots and potentially most vulnerable to deception [e.g. 17]. Here we propose a scheme of research that begins the task of identifying robot behaviours that elicit anthropomorphism in children of different ages using a non-humanoid robot.

Anthropomorphism is a widespread, likely automatic psychological bias, most often associated with animals, toys and technological devices [18]. Although top-down cognitive reasoning is involved, Gao and Scholl [9] show that low-level visual processing also traffics in animacy and intentionality, triggering a cascade of social reasoning and responses unconsciously when presented with appropriate stimuli. Although widely observed, the determinants of anthropomorphism are poorly understood. There is considerable variation in the degree to which humans anthropomorphise [19]. Differences in experience, cognitive reasoning styles and ongoing emotional attachments to other objects or people can all predict the degree to which an individual will anthropomorphise an object. If the object is perceived as sufficiently novel or complex, users are more likely to rely on their understanding of other human minds in order to understand, control and predict the object's behaviour. People who score higher on scales measuring 'need for control' and 'need for closure' are also more likely to anthropomorphise, as are those who are chronically lonely or are induced to feel lonely [20].

2 DEVELOPMENT OF ANTHROPOMORPHISM

It is unclear from the literature whether differences in anthropomorphism can also be predicted by a person's age. The traditional model suggest that young children (typically aged 3-7) are rampant anthropomorphists, treating everything they encounter as having thoughts and feelings like themselves [21]. This model predicts that by age 9 children will reliably categorise entities into those with human-thought and those without and that anthropomorphism will be rare in adults. However, everyday experience and more recent research [22] shows that older children and adults routinely anthropomorphise. To capture this, more recent models propose that anthropomorphism actually gets stronger with age, in line with increasingly sophisticated social reasoning [e.g. 23]. One of the author's (NG) [24, 25] has previously shown that children as young as three years of age are surprisingly nuanced and will anthropomorphise toys that they have a strong emotional attachment to but not other toys they own. These other toys have faces and names and the children frequently use them in imaginary play, and yet it is only those to which they are emotionally

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bonded that they treat as having thoughts and feelings. This suggests that the development of anthropomorphism is more complex than current psychological models have so far captured. Young children may, in fact, be more sensitive to variation in anthropomorphic cues than adults are.

3 BEHAVIOURS THAT ELICIT ANTHROPOMORPHISM

Users are more likely to anthropomorphise when the object has a face, body or motion that is human-like [13, 14, 15, 16]. A growing body of research is identifying the psychological impact of robot appearance on user experience and expectations, perhaps most notably the ABOT database which has compiled a range of robot appearances with associated ratings of 'humanness' [5]. However, the degree to which a robot is anthropomorphised will inevitably be an interaction between its appearance, its behaviour and the situation [26]. A static object with a face will be anthropomorphised less than an object without a face that moves contingently with the user, exhibits surprising behaviour and moves at a human-like speed. A simple white box that moves in delicate and dynamic ways is rated by users as being high on agency and intelligence despite having no personifying features [27].

There is little extant literature on the impact of behaviour on anthropomorphism in adults. Objects that act unpredictably evoke the need for control, and therefore seem more mindful than those that act predictably. In a series of studies, Waytze and colleagues [16] showed that the more unpredictable a person's computer, a novel gadget or robot was, the more participants anthropomorphised it. Users anthropomorphise more when the outcome of unpredictable behaviour is negative than when it is positive [28]. Imaging revealed that the same areas of the brain were activated when reasoning about unpredictable gadgets as typically associated with social reasoning about other humans, and that this was not the case when the same gadget acted predictably. To our knowledge, no direct replication has been done with children but Lemaignan and colleagues [29] found that while children aged 4-5 were more engaged with a robot that acted unpredictably than one that acted predictably, they subsequently anthropomorphised it *less*. More research is required to examine whether this contradiction reflects methodological differences, differences in the robot being used or developmental sensitivity.

Speed of motion has also been identified as a strong cue for anthropomorphism. Morewedge and colleagues [13] show that people are more likely to attribute mental attributes such as intention, consciousness, thought and intelligence to animals, robots and animations if they moved a natural speed than if they moved faster or slower. Wheatley *et al* [30] show that areas of the brain implicated in the perceptual and conceptual processing of biological motion and social stimuli are activated when observing geometric shapes interact.

Finally, orientation, degree and type of interaction with the user have also been shown to be important behavioural components in human-robot and child-robot interaction. For instance, Fink *et al* [29, see also 30] show that young children more readily engage with a simple robot that exhibits proactive behaviour (cuing joint attention with the child to target objects) than one that shows only reactive behaviour.

4 WHY MANIPULATE ANTHROPOMORPHISM?

Despite concerns about deception, the ethical question of whether or not robots should be designed to elicit anthropomorphism is a complicated one [3]. On the one hand, anthropomorphised robots have the potential to be emotionally confusing, especially to those users who are most vulnerable and least scientifically literate such as children and the elderly. Anthropomorphism at its best can elicit feelings of care and closeness from the user [22,24], making them more powerful tools for manipulation by unscrupulous corporations. Anthropomorphic expectations can lead to disappointment and dislike when not met and anthropomorphised objects are sometimes considered unlikable, untrustworthy and disgusting [33].

However there can be very positive psychological consequences of anthropomorphism. For instance, users who anthropomorphise their cars like them more and take better care of them than those who don't. Anthropomorphised objects have been rated as more likeable, more trustworthy and more understandable than matched items that have not been anthropomorphised [22]. And this seems to be a two-way process: liked objects are anthropomorphised more than unliked objects. Children remember and learn more from educational robots if they have anthropomorphised voice modulation than if they do not [34]. Perhaps most importantly in the context of children's companion robots, anthropomorphism has been shown to be a powerful tool for alleviating loneliness [24]. Adults who are chronically lonely anthropomorphise more than those who are not and use this as a mechanism to relieve their distress [18, 35]. Adults induced to feel lonely under experimental conditions subsequently felt less lonely if given the opportunity to anthropomorphise [ibid.]. There are many potential psychological risks but also benefits of robot anthropomorphism and the balance will need to be determined by the type of user and the purpose of the interaction. Without a better understanding of what cues elicit anthropomorphism for different users, designers have little control of this important variable.

5 PROGRAMME OF RESEARCH

It is widely recognised that significant moral confusion exists regarding the status of robots [36, 37]. In addition, wider societal concerns related to the deployment of artificial intelligence at scale motivate the study of human anthropomorphic responses to autonomous intelligent systems: robots [38]. Improved models of the human anthropomorphic response may enable engineers to design robots such that they may be more usefully understood by humans. These improved models will also provide a foundation for effective standardisation and regulation of products and services, such that products may be tested and certified as compatible with well established, internationally recognized, standards [7]. Standards compliance increases trust and acceptance of new technology, leading to increased usage and uptake of products. Eventually, such an understanding may support design of genuine human-machine relationships that don't rely on the attribution of human-like characteristics.

Our research is to expose the key drivers for anthropomorphism of robots, focusing on behaviours as distinct from robot appearance or form factor. Anthropomorphism is a human universal and creates expectations about robots that could help but also hinder. Our research has a strong methodological agenda. We and other researchers will be able to leverage this work in many ways to advance understanding and creation of new human interaction models for embodied autonomous systems. Previous literature has established unpredictable actions, speed of motion and orientation as critical behavioural cues that elicit anthropomorphism [5, 13, 14, 15, 16]. Little work has examined the importance of these cues in child-robot interaction and, what research has been done has sometimes found contradictory results [e.g. 31]. The first stream of proposed research is a systematic review of the human-robot interaction and psychological literature to identify any other potential behavioural cues that may be manipulable variables for anthropomorphism. This will include a review of databases of human-robot interaction, most importantly the PiNSoRo dataset [39] which comprises 45+ hours of videos of child-child and child-robot interaction, coded for engagement and social responses and including data on gaze direction, skeletal movements and vocalisation.

Once a set of key behavioural variables are identified that may potentially elicit anthropomorphism, we will compare their impact on user anthropomorphism. Relatively low cost non humanoid robotic platforms have been found effective for the study of naive human responses to robots, for example the R5 robot [40]. Similar commercial robots such as the Husarion ROSbot [41] and Anki Vector [42] may also serve as effective experimental platforms. As proof of concept, these will first be used to measure adults' responses after observing videos of the robot behaviours online and rating them on a series of scales (to include, among others, the Individual Differences in Anthropomorphism Scale (adult and child version) and the Godspeed) to measure anthropomorphism. Children and adults will then be filmed interacting with the robots in controlled (a lab) and uncontrolled (a science museum) conditions as they exhibit behaviours that have been previously established in the literature (e.g. speed of motion, contingent response & errors) along with those that emerge fro the piloting and secondary data analysis. Anthropomorphism of the robot will be rated using a range of age appropriate measures. The traditional model of the development of anthropomorphism predict that children at 3-4 years of age should anthropomorphise to the greatest extent, 9-10 year olds less so and adults not at all [21]. We will focus on these age groups in our studies to explore if these critical stages in the development of anthropomorphism predict differences in the effectiveness of anthropomorphic behavioural cues. Alternatively, it may be that these cues become more effective cues for anthropomorphism as users get older, reflecting increasingly sophisticated social reasoning and awareness. A contingent stream of research will explore how children and adults with autism respond to the same behavioural cues. Children with autism present a theoretically interesting comparison because anthropomorphism is conceptualised as a mis-attribution of social reasoning, a capacity known to be compromised in those with autism [43]. Yet anecdotally and in several case-studies, children with autism readily interact with robots, engage with them socially and may even be able to use them to practice and learn social skills for carry-over to their human-human interactions [44]. Children with autism may in the future be a specific target market for certain types of education and companion robots [45] so understanding how their responses are similar to or different from those of age matched typically developing children will be a valuable contribution both theoretically and practically.

6 CONCLUSIONS

There is substantial evidence that children and adults attend to robot behaviours as much as (or more than) robot appearance when attributing mind. It is unclear whether there is developmental change in this psychological bias. Here we propose a programme of research to expose the key behavioural drivers that elicit anthropomorphism and to examine how these responses vary with the age of the user and the robot design.

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