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Children's Concept of Animacy: The Humanoid Robot and the Robotic Human

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Abstract

Advances in robotics and artificial intelligence introduce increasingly capable robots to society. Such skilled robots bring into question the importance of an object's capabilities in determining its animacy. This is particularly salient among children, who make the most mistakes in distinguishing animate and inanimate objects. It is common for children to give inanimate objects animate traits; in this way, able-bodied robots could become "animate". The purpose of this study is to address whether or not providing an object with enough behavioral and intellectual capabilities can change the object's animacy. A total of 90 children (ages 3, 5, and 7) will interact with either a human or a robot that displays different levels of ability. Following each interaction period, children will be asked to attribute biological and psychological characteristics to the person or robot. Because children have been shown to link animacy with certain traits, the addition (or subtraction) of enough of these traits may come to change the overall animacy of the object.

Introduction

The field of robotics poses a new set of questions for the distinction between animate and inanimate objects. As technologies progress, robots are able to display increasing levels of intelligence and take a variety of different forms. As these advances occur, questions of life and animacy become progressively more relevant. It is especially important to note that children grow up immersed in society's most advanced technological culture, and thus will have an increasingly normative experience with robots. In addition, children err much more than adults in distinguishing animate and inanimate objects (Dolgin & Behrend, 1984; Jipson & Gelman, 2007). To address the question of animacy and advancing robotics, this study will vary the abilities of robots and humans to gain a better understanding of how abilities correlate to animacy.

Children have diverse and developing views of what constitutes an animate or an inanimate object (Beran et al., 2011; Dolgin & Behrend, 1984; Jipson & Gelman, 2007; Opfer, 2002; Opfer & Siegler, 2004). Regardless of age, children commonly struggle to classify objects that only partially align with their understanding of living things. For instance, children typically think of plants as non-living since they do not move or have a face (Opfer & Siegler, 2004). At the same time, they may consider dolls to be animate because of their human resemblance (Jipson & Gelman, 2007; Dolgin & Behrend, 1984). While this difficulty is shown regardless of age, different age groups show different tendencies when classifying these objects. The most errors are seen among 3-5 year old children, while by 7-9 years of age their errors drastically decrease and closely resemble adult responses (Dolgin & Behrend, 1984). In general, these errors over-extend animacy, as children under twelve are more animistic than teenagers or adults (Beran et al. 2011). Certain age groups, however, may diverge from this trend. While three and four year olds make the most errors, these errors are distributed in the same way as adults' errors.

Five year olds are particularly of interest as there have been conflicting results at this age. Dolgin & Behrend (1984) found that 5 year olds tended to overclassify things as animate, while Opfer (2002) found that 5 year olds were the least likely to extend animacy to a given object.

One approach to studying the animate-inanimate distinction is to look at animacy as being driven by specific characteristics. Several of these driving characteristics relate to the embodiment of the object. Consider the impact that having a face has on an object. In infancy, babies show a preference for properly configured and detailed faces (Johnson et al., 1991). While for infants this is only a visual preference, this idea of a properly configured face later influences how likely we are to judge the item as animate. The more human a face looks, the more likely it is to be perceived as animate (Looser & Wheatley, 2010). Johnson, Slaugher, and Carey (1998) also looked at the influence a face has on how infants respond to inanimate objects. Giving an inanimate object a face served to cause the same response that is otherwise exclusive to animate objects. The presence of a face can similarly cause distinctions in different living things. An animate object with a face is perceived as more animate than a living thing that does not have a face (Jipson & Gelman, 2007). Additionally, embodiment in general impacts how the object is perceived. Barneck et al. (2009) looked at the role of embodiment in determining the animacy of robots. They found that the embodiment of the robot changed how easy it was to interact with the robot and how friendly it was thought to be.

While visual characteristics are important, they often work in tandem with behavioral characteristics. In the animacy of robots specifically, visual characteristics were only salient when combined intelligence (Bartneck et al., 2009). Of the many behavioral characteristics of animate objects, there are several that have been set apart as being distinctly animate. Self-propulsion has long been thought to be one of the most prominent of these traits, as being able to move oneself can create an impression of agency (Luo & Baillargeon, 2005; Opfer, 2002). Agency is also linked to intentional actions, which in turn lead to attributing beliefs about animacy. Behaving intentionally has been shown to correlate with viewing an object as an organism and giving it biological capacities (Opfer, 2002). These two traits – self-propulsion and intentionality – combine to produce teleological action. Opfer & Siegler (2004) found that behaving teleologically is nearly as potent in determining animacy as directly telling a child that an object is alive. One final behavioral characteristic is contingency. Contingency has been shown to cause children to respond to an object in similar ways to how they respond to humans (Johnson et al., 1998).

Each of these characteristics has been shown to be associated with animacy; as such, animacy itself could be dependent upon acquiring the right combination of these traits. In this scenario, an animate object would be an object that displays enough of the right characteristics, while an inanimate object is one that does not display such traits. Opfer & Siegler (2004) considered the role of characteristics by teaching children about the characteristics of an object and seeing how this impacted their judgments of animacy. They found that when children were taught that an object behaves teleologically, they changed their classification of the object to being animate (Opfer & Siegler, 2004). This suggests that adding a characteristic to an object can change the way the animacy of the object is perceived. This additive response is seen even among living things. For instance, children rated a rat as more animate than a starfish; while both subjects were living, the rat had one more animate characteristic (a face) than the starfish (Jipson & Gelman, 2007). Lastly, this idea that adding characteristics and accuracy leads to increasing animacy is reflected in individual traits. Looser & Wheatley (2010) determined that adding more detail to a face and making it more accurate increased the animacy of the face until it hit a "tipping point". After this tipping point, each face was "accurate enough" to be considered equally animate. If such an additive pattern can exist with individual traits in animacy, it is possible that the same pattern can be seen among multiple traits. Thus, adding animate characteristics to an inanimate object may push it over the "tipping point" of animacy.

Despite this evidence, it is also possible that animacy is not simply a sum total of an object's traits. There are several ways this is supported. For instance, Jipson & Gelman (2007) found that both children and adults viewed man-made objects as inanimate, regardless of its other characteristics. Further, they found that a robodog that had more animate characteristics than a starfish was given fewer biological capacities and still viewed as less animate. In fact, their findings suggested that life (regardless of an inanimate's characteristics) is the biggest factor in determining animacy from age 4 onward. Additionally, Gelman and Gottfried (1996) found that children and adults view autonomous movement differently in animals and artifacts. While self-movement and agency were associated with causing animal movements, this was not the case for artifact movements. Because both entities had the same characteristic (autonomous movement) but were viewed differently, the characteristic alone was not determinant of animacy. Lastly, Johnson et al., (1998) found that coupling a face and contingency did not yield results that differed significantly from the results of either trait on its own. These findings suggest that the "tipping point" of animacy cannot be reached by simply giving an inanimate object multiple animate traits.

Robots propose a practical way to address this characteristic driven approach. Today's robots have the capacity to embody many – if not all – of the traits commonly associated with animacy. If robots can be considered animate, then this would support the idea that animacy is based on the traits that are displayed. If robots are not considered to be animate, then animacy may not be based on the number of traits an object has. To determine if there is an additive effect of traits, it animacy will be broken down into the attributes given to the object. Specifically, these attributes will be biological (does it eat? sleep? require food?) and psychological (can it think? be happy or sad? make choices?). In previous studies, robots and certain inanimate objects have been commonly given psychological, but not biological, abilities (Jipson & Gelman, 2007; Beran et al., 2011). Each of these past studies, however, considers only one or two characteristics and does not consider an additive effect of multiple characteristics on animacy.

The purpose of this study is to assess how characteristics impact children's views of animacy by comparing the perception of a robot and a human. For each subject, multiple trials will add characteristics (robot) or take them away (human). The robot's abilities will range from being highly inanimate (turned off) to seeming highly animate (fully functioning, interactive, mobile, and contingent). The human's abilities will vary in the same manner – from fully interactive to acting as a statue and being completely nonresponsive. By varying each subject's abilities, it will be possible to determine how animacy changes with abilities as well as the range of animacy that both the human and the robot can exhibit. This study expands upon previous research by using a highly humanistic robot that can display nearly all of the aforementioned characteristics. In addition, this study addresses the characteristic driven approach from multiple angles:

characteristics are added to an inanimate object and also taken away from an animate object. This two sided approach ensures results that are not contingent on technology; the fault cannot entirely fall upon a robot that "is not good enough". Thus this study proposes a way to take a comprehensive approach to the role of characteristics in making the animate/inanimate distinction.

Method

Participants. Children ages 3, 5, and 7 will be recruited for this study. The 3 and 5 year olds will be recruited from a local preschool, while the 7 year olds will be from a local elementary school. Each age group will consist of approximately 30 children.

Procedure

Familiarization Trials. The UBTech Alpha 2 Robot (one of the leading commercial humanoid robots) will be used for all robot trials. All participants will be familiarized with the robot via four QuickTime™ videos. Two of these videos show the robot interacting with people in various ways, while the other two show it performing tasks on its own. In the interaction videos, the robot will interact contingently with people and will show a variety of different interactive abilities (e.g. telling stories, doing yoga). The independent videos will focus on autonomous abilities like the way it moves and independent tasks. These videos will be viewed in one session, with breaks between each video (approximately 3 minute videos with a 1 minute break). If a child becomes distracted, an experimenter will redirect their attention to the video.

Test Trials. Each participant will complete six test trials: three robot and three human. In these trials, both the human and the robot will display a range of animate characteristics. This range of characteristics will be broken down into animate, robotic, and still trials. For each of the human trials, a different experimenter will be used so that children do not carry information over from one trial to another. For all trials, a consistent experimenter (E1) will introduce the subject of the trial.

Human Trials

Human-animate. E1 will introduce the subject of the trial by saying "I want you to meet one of my friends (name of experimenter - referred to as E2), can you say hi?". After this brief introduction period, E1 will have to leave to go finish up a task in another room, and will ask the child to keep their friend company for a few minutes. E2 will then proceed to sit by the child and interact with them normally (asking how they are, things they are doing that day, things they like, etc.). E2's responses will be animated and responses will be inflective/vary in volume when appropriate. After several minutes, E1 will return to the room, thank the child for keeping E2 company, and have them say good-bye as E2 has to go home.

Human-robotic. E1 will introduce a different subject, this time saying "I want to show you something pretty cool - this is Bot. Bot can do a bunch of things, watch!" E1 will demonstrate how to ask Bot to do a non-interactive task, like sitting down, standing up, or telling the weather. Bot's movements will be somewhat rigid, with minimal facial expressions and little to no inflection in vocal responses. After this demonstration, E1 again has to leave the room, and asks the child to try seeing what Bot can do. The child will lead all interactions from this point and Bot will only respond to specific requests of things to do. When E1 returns (minutes later) they will apologize for having to leave so suddenly and ask Bot to do their favorite trick before leaving – a somersault!

Human-still. E1 comes into the room alone, and tells the child they need to move a statue for a friend into the room for a few minutes so they can finish another task they are doing. After informing the child, E1 will leave and come back pushing E2 on a rolling desk chair. Once they are in the room E1 will say "I just need a minute to go finish up in the other room, you're welcome to look at this though. It doesn't move by itself, but you can move it just like a doll". E1 leaves, and the child is free to look at E2. E2 is to remain completely still for the duration of this trial, and will arrange for this (e.g. tying back long hair that could cause irritation, wearing a sweatshirt to hide breathing, keeping eyes closed to avoid blinking). If the child decides to move them, they are not to resist but to move like a doll would – imagining stiff joints. E1 will return, tell the child they're all finished, and then roll E2 back to the other room.

Robot Trials

Robot-animate. E1 will introduce the UBTech robot saying "I want you to meet one of my friends, this is Tommy! Can you say hi?" Tommy will be programmed to respond to the child in this trial, and will respond to the child's greeting. E1, realizing they didn't finish up in the other room, will leave the child with the robot, asking them to "entertain Tommy for a bit, I know he loves yoga and telling stories. I bet if you ask he'll do that with you!". The child can then play with and talk to the robot, not necessarily asking to do one of these things with the robot. After a few minutes, E1 will return and ask the child what they did with Tommy while they were gone. If the child says they did something, E1 will comment that it sounds like they'll be good friends and if they didn't do anything E1 will seem sad that the child didn't like their friend. E1 will then "take Tommy home".

Robot-generic. E1 will bring the UBTech robot into the room saying "I want to show you something pretty cool, this is Bot. Bot can do a bunch of things, watch!" E1 will then demonstrate how to ask the robot to do a non-interactive task, like moving in a certain way or telling them the weather. E1 will invite the child to ask a similar question, and then realize they have to run out real quick saying "I know he doesn't do much, but why don't you try those things I just did?" E1 will return in a few minutes to take Bot out of the room. After thanking the child for being patient while they had to work, they will have Bot perform their favorite task – a yoga pose!

Robot-still. E1 brings the UBTech robot into the room (turned off) saying "Is it okay if I leave this here? I'm trying to clean up in the other room and need a bit more space. You're welcome to look at it." The robot is left near the child for their observation. After a few minutes, E1 returns having finished cleaning and needing to put the robot back where it belongs.

Each trial will last no more than 10 minutes, and both a human and a robot trial will occur (in random pairs) every other day, for a total of 6 days. Immediately following the test trial, the child will be asked a series of questions by a different experimenter (not E1 or the E2 for the current trial), who will return to the room with the child and ask them "a few questions on what they thought of [the object or the name of the person/robot]." To check general understanding, the child will be asked if they remember [the object/person/robot] and what they did with them. The following questions will focus on biological and psychological capacities and come from Opfer

(2002). The biological questions will be: “Can it grow?”, “Can it die?”, “Does it need food?”, “Does it need water?”, “Does it need something”, “Can it make more little ones like it”, and “Is it alive?”. Psychological questions consist of: “Can it want something?”, “Can it be happy?”, “Can it make choices?”, “Can it think”, “Can it see?”, “Can it feel pain?”, and “Can it make plans?”.

The scoring of these responses will be broken up by biological or psychological attributions. In each category, a “yes” response will receive a score of 2 and a “no” response will be a 0, with any “don’t know” responses receiving a score of 1. This scoring has been chosen as a “don’t know” response is likely to demonstrate confusion or indecision on an ability, which could indicate that it has properties of both the yes and no response. The highest (most animate) score for either category will be a 14 (for a total of 28), with the lowest score (least animate) being a 0. As a final way to address animacy in general, the 5 and 7 year olds will be asked to give an overall response to how “alive” the trial’s subject is. Responses will be scored similarly to the 0-2 scale above but will be shown with a thumbs up, thumbs down, or in between.

Results/Inferences

Analyses of variance will consider a 2 (human vs robot) x 3 (still, robotic, animate) design. Both agency and condition will likely have a significant impact the animacy scores and aliveness ratings, and both will likely produce main effects. Additionally, it is also possible to see an interaction between the agent and condition for certain trials.

One of the first expected results is a main effect of the agent. This will be gauged by the total animacy score that combines biological and psychological capacities. It is likely that the human will receive higher animacy scores than the robot, regardless of condition. Such a result would support that animacy may not be based upon characteristics because one item can score higher than another, regardless of ability. In contrast, there will also likely be a main effect of condition, wherein the animate condition will score higher than the still condition (with the robotic falling somewhere between) regardless of the agent. This supports the characteristic approach given that an item with more abilities scores higher than an item with fewer abilities, independent of the item itself. Since these two results seem to contradict each other, it will be important to look at other measures of animacy.

In contrast to the survey, the “aliveness test” (thumb rating scale) provides the child’s basic response to the object – either it is alive, not alive, or somewhere in between. This test is a simple and direct way to categorize animacy, instead of basing it on behavioral and mental characteristics. For these results, the main effect of the agent would be predicted, as a child’s instinctive response would be to view a human as animate and a robot as inanimate. However, there may not be a main effect of condition for the same reason; the instinctual response may be that the robot, regardless of ability, is an inanimate object. In this case, animacy as characteristics is not supported because children’s most direct response is that the robot is not human. If this main effect of condition did occur, then this would support the characteristic based approach to animacy. Should this be the case, it again leaves potentially conflicting results (where the main effect of agency seems to reject the characteristic approach but the main effect of condition supports it), making analyses of the interactions between agent and condition ever more important.

It will be important to consider the range of animacy scores between conditions as a factor of agency. While the values are different (as measured by the main effects) it may be that varying the condition has a different impact on the animacy scores for the different agents. For instance, the human may have a very small range of animacy when compared to the robot, because children instinctively know that a human is animate, even if they do not seem to have any abilities. In this case, the robot – which while viewed as less animate – has a greater potential to change its animacy than did the human. Despite this seemingly greater flexibility, this goes against the characteristic approach for two reasons. First, if behavioral characteristics are the main factor in determining animacy, then these characteristics should have the same effect on animacy scores, regardless of agent. That is to say that adding contingency, for example, should increase the robot's and the human's score by the same amount regardless of what the score actually was. Second, this greater flexibility does not necessarily imply that the robot can achieve animacy. For instance, even if the robot's scores vary from 0 – 14, their highest score is still only half of the full range of animacy. To confirm this idea, the aliveness scale should be compared across conditions. If the animate robot is still getting the "thumbs down" then it is still being viewed as inanimate – despite the greater flexibility the robot seems to have.

Next, animacy scores will be broken down into biological and psychological abilities. Biological questions will likely show an effect of agent, while the psychological questions may show an effect of condition. The human is likely to be given more biological attributes than the robot, regardless of condition. This would indicate that no matter how life-like a robot may seem, it will not take on biological capacities. Such evidence would go against the idea that an object's animacy is determined by the characteristics it displays, as children would not give even a highly functional inanimate object biological tendencies. Psychological capacities, however, have been shown to be connected to different traits and thus are likely to respond to condition. Children are more apt to give psychological tendencies to objects with a face (Jipson & Gelman, 2007) or objects that display intelligence (Beran et al., 2011). As such, the animate condition for both the human and robot trials should show the highest scores in terms of their psychological capacities. If this occurs, it would support the characteristic approach since these animate capacities are given out as a function of behavioral characteristics.

Finally, scores will be compared across ages. Trends between ages could occur for total animacy, or by how the total scores are broken down. For instance, younger children are more likely to give biological traits to inanimate objects (Jipson & Gelman, 2007; Opfer, 2002). In keeping with this, older children strongly favor giving out psychological abilities (Opfer, 2002). Further, it would be interesting to note whether any biological or psychological traits stand out in terms of how often then are accepted or reject with the human or the robot. For instance, several of the psychological traits are linked to emotions. Beran et al. (2011) found that children are more likely to give inanimate objects psychological traits relating to memory and cognitive abilities than understandings of emotion. This same aversion could occur with biological traits as well. Such trends and distinctions would be useful in better understanding how children understand animate and inanimate objects.

In general, these results will not be representational of how people perceive robots in everyday life. The study is designed to give robots the best prospect for being life-like, while the humans are set up to be unrealistically inanimate. In both animate conditions, the subjects are presented excitedly and with human names. In the inanimate conditions, subjects are not given identities or capabilities. It is therefore possible that the children provide answers that agree with what the adult is saying, rather than what the child actually believes. This effect will be minimized by having a different experimenter ask the survey questions, so the child does not feel pressured to agree with E1's beliefs. It is also possible for the robot trials to be influenced by order effects since each child in the same condition is seeing the same robot (unlike in the human condition, where it is a different adult each time). By familiarizing the child to the robot's abilities before seeing the trials, the child should come to understand its abilities, just as they have a prior understanding of human's abilities before the trials. Lastly, with the exception of the 7 year olds, these children are at the most animistic ages and are the most likely to give a robot life-like traits.

This study is meant to reveal the extremes of how "alive" robots and humans can be. The results will speak to the future of intelligent robots: if animacy comes from displaying the proper traits, then robots could potentially rise to the same level of animacy as humans. If this is not the case, then perhaps robots will never reach this level of advancement. Further, the results will lead to the question of whether or not we *want* robots to be able to do this. This is especially relevant when considered with the results of the human trials: if a low-functioning human can seem less alive than a robot, then robots could come to play a major role in our everyday interactions. This study will also shed light on the balance between biological and psychological capacities in determining animacy. Currently, biology is one of the main ways that children decide if an object is alive (Jipson & Gelman, 2007). As such, children are more liberal with their attribution of psychological properties (Beran et al., 2011). By looking at this spectrum of abilities and the breakdown of how children attribute these properties, the impact of an object's characteristics can be observed. This will either support or refute the idea that living things are defined by a collection of characteristics that we learn about early in life and come to associate with being alive.

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