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Influence of Animallike Affective Non-verbal Behavior on Children's Perceptions of a Zoomorphic Robot*

Isobel Voysey^{1,4}, Lynne Baillie^{2,4}, Joanne Williams³, and J. Michael Herrmann^{1,4}

Abstract—Zoomorphic robots are a promising tool for animal welfare education and could be used to teach children that animals have minds and emotions and thereby reduce acceptance of cruelty towards animals. This study investigated the influence of animallike affective non-verbal behavior on children's perceptions of the attributes and mental abilities of a zoomorphic robot, as well as their acceptance of cruelty towards it. Children who interacted with a robot that displayed animallike affective non-verbal behavior ascribed a significantly higher level of mental abilities. Higher levels of perceived mental abilities were not generally correlated with lower acceptance of cruelty but higher levels of perceived social attributes were. Post-hoc analysis of reasoning given for unacceptability of cruelty found that the group of children who made moral judgments about the cruelty had rated the zoomorphic robot as significantly more animate.

I. INTRODUCTION

Animal welfare education at an early stage in life is beneficial for both animals and children. As children learn about responsible animal care they are more likely to have healthy, safe relationships with animals throughout their lives [1]. However, it is not appropriate to use live animals in animal welfare education (AWE) due to reasons including welfare concerns, hygiene issues, and the potential for bites and scratches [2], [3]. Current AWE programmes conducted by the Scottish Society for the Prevention of Cruelty to Animals (Scottish SPCA) reach more than 200,000 schoolchildren each year [4] and use a combination of videos, games, and soft toys. Robots are a promising tool for AWE and the Scottish SPCA has recently begun to incorporate robotics, using a modular kit that the children build, to highlight similarities between robots and animals in terms of senses and decision-making processes [5]. Educational programmes that use robotics to educate children about animals may result in improved outcomes; a recent study [6] found greater improvement in children's belief of sentience and welfare knowledge about rabbits for a group that interacted with mechanical rabbits compared to a group that interacted with soft toy rabbits.

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Zoomorphic (animallike) robots are the most appropriate type of robots for use in AWE, since they use animal attributes for their form and increasingly for their behavior. They also draw upon existing animal schema held by the user. Therefore, the animal nature of the robot has a large influence on interactions with it. However, prior research has not established how attitudes towards and relationships with animals impacts perceptions of zoomorphic robots, which will be important for promoting compassion and responsibility in AWE. In addition, attitudes towards robots may influence children's engagement with the AWE programme and willingness to treat the robot in a kind manner. In order to develop a zoomorphic robot for use in AWE, it is important to further investigate the effect of children's views on animals and robots on their attitudes and behaviors towards a robotic animal.

Another important factor for the interaction is how animate the children believe the robotic animal to be [7], [8]. The level of animistic beliefs a person holds about an object or being is shown by what mental, social, and moral characteristics they attribute to it [9]. Recent research investigating a zoomorphic robot as a potential replacement for therapy dogs found that the extent to which children held animistic beliefs about the interaction partner – either a dog or a robot – correlated with their enjoyment of the interaction [10]. Perceived animacy is even more important in AWE beyond increasing enjoyment, as the robot needs to provide a suitable parallel to a live animal, particularly in terms of richness of experience and moral standing, to promote empathy towards animals [7]. Previous research has found associations between children's beliefs about animal minds, namely their belief in animals' capacity for intelligence and emotions, and factors relating to positive interactions with animals [11]. Since beliefs about minds are a key factor, this study aimed to extend investigations into perceived animacy by digging deeper into the mental capacities that children ascribe to a robotic animal, based on work done on the mental states that children attribute to humanoid robots [12].

Furthermore, this study looked to see if robot behavior itself impacted the level of animistic beliefs held by the children by comparing attribution of mental states to a robot that displayed animallike affective non-verbal behavior (AANB) and a robot that did not display affective non-verbal behaviors (without AANB). Affective non-verbal behavior (ANB) has been shown to influence people's perceptions of robots, including their animacy [13]. Previous studies into ANB [13], [14] have considered humanlike, animallike, and robot-specific behaviors, either on their own or in

combination. A study with a humanoid robot [13] found that, while robot-specific ANB (expressed through colored LEDs) had impacts on perceptions of the robot, humanlike ANB had a greater impact, and a combination of humanlike ANB and robot-specific ANB did not increase this effect. We hypothesized a similar relationship would hold for a zoomorphic robot and AANB. Purely animallike ANB is also the most appropriate in the context of animal welfare education. Several recent studies [15], [16] have looked at expression design and emotion recognition in zoomorphic robots and have shown that affective displays by zoomorphic robots are recognisable. However, these studies are limited to videos and the affective displays are not incorporated into live interactions. In this study, the focus was not on design and recognition of a limited set of discrete emotions, but rather the display of general affective non-verbal behavior in an interaction and its impact on children’s perceptions of the robot.

A. Aims

Overall, the aims of this study were to:

- Assess the impact of children’s prior beliefs about animals and robots on their interaction with a robotic animal
- Discover what mental capacities children ascribe to a robotic animal and compare with those they ascribe to live animals
- Assess the impact of robot behavior on perceived robot attributes by comparing one version with AANB and one without
- Investigate children’s acceptance of and reasoning about cruelty to a robotic animal

II. METHODS

A. Participants

A between-subjects study with 49 children was conducted: 19 female, 29 male, 1 preferred not to specify, aged 7–10 years ($M=8.96$, $SD=0.58$). Participants were recruited from one Primary 4 class and one Primary 5 class in a mainstream primary school in Edinburgh, UK. Written consent was obtained from the headteacher to test in the school. Information sheets were provided to parents and children, and those who gave consent were recruited. Participation was voluntary so no additional rewards or motivations were provided, though participants were presented with a certificate at the end of the experiment thanking them for their participation.

B. Robot

The robot used for this experiment is the MiRo-E, a biomimetic robot designed by Consequential Robotics¹. MiRo has a mammal-like appearance, with eyes, large ears, and a tail (see Fig. 1). The robot has two HD cameras, touch sensors on the head and back, position and detection sensors (sonar, light, and cliff), and four microphones. It has

two differential drive wheels, a neck with three degrees-of-freedom, and cosmetic features that mean it can wag its tail, rotate its ears, and open and close its eyelids. This is all controlled using a Raspberry Pi 3B+.

The robotic behaviors for both experimental conditions were developed using the control system pre-implemented on MiRo and its configuration options. The controller uses brain-based robotics with three layers of processing to incorporate affect and simple reflex behaviors. Affect is modelled internally using the circumplex (arousal-valence) model [17], and is influenced by sound and light levels, presence of faces, jerky movements, and tactile interactions. MiRo can express affect through lights in its back, movement of its ears, eyes, and tail, and through its voice (based on work by Moore and Mitchinson [18]). Behavior generation is achieved through selecting an action from approach, avert, flee, halt, mull, orient, and retreat every 0.02 seconds. The action with the highest priority is selected, where priority for each action is given by a pre-defined combination of affect and audio, visual, and tactile information. For example, flee has a high priority when valence is low and arousal is high and approach has a high priority when valence is high and arousal is high.

Participants were assigned to one of two conditions: with animallike affective non-verbal behavior (AANB) or without. The assignment was done to ensure an approximately equal gender and age split across the conditions. The condition with AANB expressed affect through the ears, eyes, tail, and voice, see Table I for how arousal and valence levels were expressed by each of the features. After initial piloting, the model was adjusted to exaggerate the movement of the ears; the linear function used to connect arousal to ear position was swapped for a sigmoid function. Expression through lights was disabled since it is a robot-specific affective non-verbal behavior and has no parallel in mammals. The condition without AANB did not express affect through ears, eyes, tail, or lights. However, the robot in this condition still produced vocalizations, corresponding to medium arousal and neutral valence, as it was felt the absence of audio feedback from the robot could be a confounding factor. Both conditions used the same internal affect dynamics (thereby resulting in the same action selection) and a platform parameter was adjusted

TABLE I
EXPRESSION OF AROUSAL AND VALENCE LEVELS BY DIFFERENT
FEATURES IN CONDITION WITH AANB

Feature	Dimension			
	Arousal		Valence	
	Low	↔ High	Negative ↔	Positive
Ears	-	-	Pointing sideways	Pointing forwards
Eyes	Closed	Open	-	-
Tail	Low amplitude	High amplitude	Still	Wagging
Voice	Low amplitude and tempo	High amplitude and tempo	Low pitch	High pitch

¹<https://www.miro-e.com/>

to increase the rate of change of the dynamics so that a wide range of affects could be shown within the interaction time.

C. Study Design

The study took place at the school the participants attended. Due to restrictions surrounding external visitors during the COVID-19 pandemic, the questionnaires were administered by class teachers during school time and the interaction sessions were conducted outside in the playground on two consecutive days—the interaction sessions for the younger class happened on the first day and for the older on the second day. Table II shows an overview of the procedure followed for each participant during the study. The study received ethical approval from the university’s ethics board.

Before the researcher came into the school to conduct the interaction sessions, the class teacher used materials provided by the researcher to explain the study to the class and asked them to complete consent forms. Each participant who provided consent then completed the pre-interaction questionnaire. The teacher was able to help participants if they had any questions. A similar procedure was used for the post-interaction questionnaires.

During each participant interaction session, the participant was collected from the classroom and brought to the interaction area. Fig. 1 shows the setup used for the interaction sessions. They were given a short reminder of the procedure for the interaction session and given an opportunity to ask any questions. Next, the participant was asked by the researcher to perform three brief tasks to familiarize

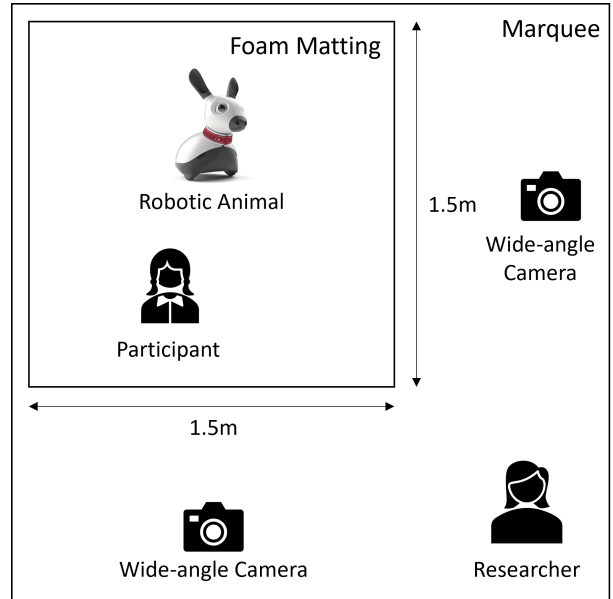


Fig. 1. Layout of interaction area

themselves with the robotic animal. These tasks were framed as checking the robot could sense the participant via sight, hearing, and touch, and enabled the participant to get an awareness of some of the robot’s sensory capabilities prior to the freeform interaction. This was done since it was expected that many participants would not have interacted with a robotic animal before and motivated by advice from Kidd and Brezeal [19]. During this phase, the robot did not perform any translation to facilitate performance of the tasks. For the freeform interaction phase the participant was told that they had three minutes to interact with the robot but that they could stop early if they wanted. They were requested to remain on the mat and to keep the robot on the mat. The researcher only intervened if the participant showed signs of distress, there was a risk of damage to the robot, or to prompt the participant to return the robot to the mat. The researcher gave short replies to any questions asked by the participant during the interaction but neither initiated conversations nor reacted to the interaction. Video was recorded of the familiarization tasks and the freeform interaction so that behavioral analysis could be conducted at a later date.

D. Measures

The following standardized and customized questionnaires were used. They are given in the order they were presented to the participants. Items 1–3 were only asked pre-interaction, items 4–5 were asked both pre- and post-interaction, and item 6 was only asked post-interaction.

1) *Demographics*: This comprised four questions on age, gender, number of siblings, and current pet ownership.

2) *Attitude to animals*: Participants’ prior attitudes towards and beliefs about animals were measured using two scales: the Short Attachment to Pets Scale (SAPS) [20] and the Belief in Animal Minds scale (BAM) [11]. Both scales

TABLE II
SUMMARY OF PROCEDURE USED FOR EACH PARTICIPANT

Session	Phase	Activity	Duration
1	Consent gathering	Class teacher reminded participant of study design and requested they complete the consent form.	5 mins
	Pre-interaction questionnaire	Participant completed the questionnaire.	20 mins
Session 1 total: 25 mins			
2	Introduction	Researcher introduced the participant to the robotic animal and reminded them of session structure.	2 mins
	Familiarization tasks	Participant prompted to complete three tasks to familiarize them with the robotic animal’s sense of sight, hearing, and touch (order randomized).	2 mins
	Freeform interaction	Participant was given three minutes for freeform interaction with the robot.	3 mins
Session 2 total: 7 mins			
3	Post-interaction questionnaire	Participant completed the questionnaire.	15 mins
	Certificate presentation	Teacher presented the participant with a certificate thanking them for participation.	5 mins
Session 3 total: 20 mins			

are designed for use with children and young people. SAPS is a 9 item scale (one of which requires reverse coding) and BAM is a 5 item scale. Both measures use 5-point Likert scales with higher scores representing a greater attachment to pets and a greater belief in animals' abilities to be clever and experience emotions, respectively. The BAM scale was asked in reference to both dogs and rabbits, since these were two animals that it was expected the participants would believe the robot to be most like, based on the animals most commonly associated with MiRo by participants in [15] and use of MiRo as a comparison to therapy dogs by [10]. Internal consistency of the scales was assessed using Cronbach's alpha. The SAPS was found to be internally consistent ($\alpha=0.87$) but the BAM measure was not internally consistent for dogs ($\alpha=0.42$) or rabbits ($\alpha=0.64$). However, this could be improved by separating out the measure referring to cleverness from those referring to experiencing pain and emotions (dog $\alpha=0.60$; rabbit $\alpha=0.72$).

3) *Awareness of robots*: Participants were asked if they had any robotic animals at home and to provide the type if they did. They were also asked to list any robots they knew, real or fictional, to provide context for their social acceptance of robots.

4) *Attitude to robots*: This measure probed participants' feelings about robots in social settings, particularly ones with limited functionality. Participants used a 5-point Likert scale to rate their agreement with a statement about liking robots as well as statements on social acceptance, adapted from [21]. Internal consistency was found to be good, both pre-interaction ($\alpha=0.87$) and post-interaction ($\alpha=0.87$). The pre- and post-interaction average ratings were compared to analyse changes in a participant's social acceptance of robots.

5) *Perceived attributes and mental abilities of robotic animals*: This comprised of three separate scales to measure participants' perceptions of the following attributes: animacy, anthropomorphism, and likeability; mental abilities; and moral standing. Participants were provided with images of three robotic animals (Sony's AIBO dog robot, Consequential Robotics' MiRo, and Hasbro's Joy for All cat) to give a visual prompt to guide them. The pre-interaction average rating for each measure or sub-measure was compared with the post-interaction average rating to analyse changes in a participant's perception of robotic animals.

The questions for the first measure were a customized version of the anthropomorphism, animacy and likeability measures in the GODSPEED questionnaire [22], altered for children aged 7–10. Wording was generally taken from the questionnaire used by [10] with 11–12-year-olds and simplified further where deemed necessary. Each of the nine items required participants to select a position on a 5-point semantic differential scale between two descriptions of the robot. Internal consistency was not acceptable pre-interaction (anthropomorphism $\alpha=0.56$; animacy $\alpha=0.66$; likeability $\alpha=0.72$) but was acceptable or good post-interaction (anthropomorphism $\alpha=0.80$; animacy $\alpha=0.73$; likeability $\alpha=0.88$). It was expected that some measures might not be internally consistent pre-interaction since the participants were making

judgments based on a wide range of prior exposure to robots.

The set of questions on mental abilities were based on the questionnaire investigating the attribution of mental states in humanoid robots used by [12]. The original questionnaire contained categories for perceptual, emotional, intentional, imaginative, and cognitive abilities, but the category about imagination was omitted because very few abilities apply to animals. There was overlap with four of five measures on the BAM scale, so the fifth was added to the list and the questionnaire was altered to be on a 5-point Likert scale instead of yes/no. This way a comparison could be drawn between participants' beliefs about the minds of live animals and robotic animals. Finally, some questions were added on self-awareness abilities, based on the dimensions of animal consciousness categorized by [23]. Internal consistency for each of the categories was generally acceptable pre-interaction (perception $\alpha=0.77$; emotion $\alpha=0.83$; intention $\alpha=0.54$; cognition $\alpha=0.80$; self-awareness $\alpha=0.45$) and post-interaction (perception $\alpha=0.81$; emotion $\alpha=0.86$; intention $\alpha=0.59$; cognition $\alpha=0.88$; self-awareness $\alpha=0.66$). Scales could not generally be made more internally consistent by removing items. The exception is the intention subset of items, which could be made more consistent by removing the item "does things on purpose" (pre-interaction $\alpha=0.61$; post-interaction $\alpha=0.83$). Internal consistency for self-awareness was low, though this is likely due to the scale only comprising two elements [24].

The measure on moral standing was adapted from a measure used to investigate acceptance of animal cruelty [25]. Acceptance of cruelty to beings has previously been used as a way of assessing children's perceptions of those beings' moral standing [9]. Items specific to animals were adjusted to make them apply to robotic animals (for example, "forget to feed it for a few days" was replaced by "forget to charge it for a few days"). Internal consistency was found to be good, both pre- ($\alpha=0.87$) and post-interaction ($\alpha=0.89$). In the post-interaction questionnaire, a free-response question was included, asking participants to explain their reasoning behind their response to the acceptability of kicking a robotic animal. Themes were extracted using constant comparative analysis [26].

6) *Opinions about the robot*: The participants' opinions about the robot were collected through questions on enjoyment, likes and dislikes, and the animal type the participant perceived the robot to be most like.

The enjoyment scale was a five-item five-point Likert scale measure based on [10] that covered statements on liking the robot, enjoyment of interaction, perception of the robot's enjoyment, desire to interact with again, and desire to own one themselves.

The participants were asked what they liked most about the robot and what they would like to be different. The participants were also asked to provide what animal they thought the robot was most like and why. Themes were extracted using constant comparative analysis [26].

III. RESULTS

Of the 49 participants, 45 completed all aspects of the procedure (the interaction and both questionnaires). However, during two interaction sessions, there was an error with the connection established with the robot which resulted in no movement in any of the kinematic joints, i.e. the neck and wheels. This was a large change from the normal robotic behavior. Therefore, the data from these two participants were excluded and the following section presents the results from the remaining 43 participants, 20 in the condition with AANB and 23 in the condition without AANB.

A. Impact of Pet Ownership

The majority of children (33 out of 43) owned one or more pets. The most commonly owned pets were dogs (15 children) and cats (15 children), followed by fish (8 children). Dog ownership was linked to greater attachment to pets and greater belief in dog minds (Mann-Whitney U tests: $U=111.5$, $p=0.01$, and $U=129$, $p=0.04$, respectively). However, neither pet nor dog ownership was linked to participants' attitudes towards the robot.

B. Perceived Attributes and Mental Abilities

Wilcoxon signed-rank tests were used to compare each participant's ratings before and after the interaction. Participants who interacted with the robotic animal that displayed AANB rated the robotic animal significantly higher in terms of its perceptual ($p=0.03$), emotional ($p=0.04$), and cognitive ($p=0.03$) abilities afterwards. The participants who interacted with the version without AANB did not rate the robot significantly differently in any areas following the interaction.

Mann-Whitney U tests were also used to compare the change in participants' ratings for attributes and abilities across the experimental conditions. This further highlighted a difference in how participants' beliefs in perceived self-awareness abilities changed ($Z=2.06$, $p=0.04$). Participants in the condition with AANB had an increase in their belief of this ability ($M=0.43$, $SD=0.86$) while those in the condition without AANB had a decrease in their belief ($M=-0.07$, $SD=1.06$).

Children rated the robot's ability to be clever, and feel happiness, sadness, pain, and fear as significantly lower than both dogs and rabbits (Wilcoxon signed rank tests: $p<0.001$ for every item and each of the two animals).

C. Acceptance of Cruelty

Table III shows the correlation of post-interaction measures with acceptance of cruelty. Negative correlations show that as the participants' perceptions of the robotic animal's social attributes and mental abilities increase, their acceptance of cruelty towards it decreases. For the condition with AANB there were significant, though weak, negative correlations with acceptance of cruelty and each of perceived anthropomorphism, animacy, and likeability. However, these correlations were not significant for the condition without AANB. There was no significant difference in acceptance of

TABLE III
CORRELATIONS WITH ACCEPTANCE OF CRUELTY

Measure	Association with acceptance of cruelty					
	With AANB		Without AANB		Both conditions	
	r_s	p	r_s	p	r_s	p
Attachment to pets	0.02	0.29	-0.25	0.60	-0.17	0.34
Social acceptance of robots	-0.28	0.05	-0.46	0.12	-0.39	0.01*
Enjoyment	-0.47	0.05	-0.26	0.08	-0.39	0.007**
Perceived anthropomorphism	-0.41	0.03*	-0.26	0.31	-0.32	0.02*
Perceived animacy	-0.39	0.04*	0.04	0.71	-0.17	0.09
Perceived likeability	-0.49	0.004**	-0.57	0.07	-0.54	0.0007***
Perceived perceptual abilities	-0.34	0.05	-0.30	0.09	-0.29	0.01*
Perceived emotional abilities	-0.29	0.32	-0.21	0.20	-0.21	0.11
Perceived intentional abilities	-0.19	0.34	0.12	0.88	-0.01	0.65
Perceived cognitive abilities	-0.19	0.23	-0.15	0.45	-0.17	0.19
Perceived self-awareness abilities	0.05	0.76	-0.17	0.38	-0.07	0.65

r_s : Spearman's rank correlation coefficient

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

Bold value indicates statistically significant results

TABLE IV

THEMES IDENTIFIED FROM THE FREE RESPONSE ANSWER JUSTIFYING WHY THE PARTICIPANT THOUGHT IT WAS ACCEPTABLE/UNACCEPTABLE TO KICK A ROBOTIC ANIMAL

Themes	With AANB	Without AANB
Unacceptable		
Could break/damage robot	10	12
It is mean/cruel to robot	6	5
Robot has feelings	3	2
Societal expectations	2	2
Robot is like humans	2	1
Acceptable		
If robot were mean to you	2	-
Undecided	-	1
None provided	1	-

cruelty between conditions (Mann-Whitney U test $U=253.5$, $p=0.57$) so conditions were pooled together for further analysis which revealed significant negative correlations between acceptance of cruelty and social acceptance, perceived perceptual abilities, and participant enjoyment.

Table IV shows the reasoning given by participants to justify why they thought kicking a robotic animal was acceptable or unacceptable. The length of responses ranged from one to 24 words, with a median length of five words. The majority of participants ($N=40$) thought it was not acceptable or not at all acceptable to kick a robotic animal. The reason most commonly for this was that it could damage or break the robot. The second most common reason was that it was "mean" or "cruel". Both of the participants who believed it was somewhat acceptable to kick a robotic animal reasoned that it would be acceptable in response to meanness from the robotic animal itself. Analysis using Fisher's Exact Test (chosen due to small sample sizes) found no significant difference between the conditions ($p=0.86$).

A post-hoc comparison across the conditions separated the participants into two groups based on their reasoning

given for unacceptability of cruelty. One group comprised those who attributed a level of moral standing to the robot, either by referring to the robot’s feelings, comparing it to humans, or describing the act of kicking the robot as “mean” ($N=14$, age: $M=8.76$, $SD=0.65$, gender: 8 female, 6 male). The other group comprised those who referred only to the fact that the robot could be damaged or that there was a societal expectation not to kick things, whether objects or people ($N=27$, age: $M=9.13$, $SD=0.54$, gender: 9 female, 17 male, 1 preferred not to say). The two participants who believed it was somewhat acceptable to kick a robotic animal were excluded from this analysis. There were no significant differences between the groups in terms of age, gender, or pet ownership, but the group that attributed moral standing to the robot had rated its animacy significantly higher than those who did not (moral standing group: $M=4.13$, $SD=0.75$; other group: $M=3.23$, $SD=1.18$; Mann-Whitney U test $U=267$, $p=0.03$). They also attributed a significantly higher level of abilities in perception ($p=0.02$), emotion ($p=0.04$), and intention ($p=0.009$).

D. Evaluation of Experience

Participants in both conditions reported high levels of enjoyment on average (with AANB: $M=3.78$, $SD=1.27$; without AANB: $M=3.94$, $SD=0.97$) and this did not differ between the conditions ($Z=-0.09$, $p=0.93$). However, two participants in the condition with AANB and one participant in the condition without AANB strongly disagreed with four or five of the statements about enjoying the interaction. These participants seemed to have been dissatisfied when MiRo did not meet their expectations, namely that it could not follow verbal commands and could not play football. Participants who enjoyed the interaction liked a variety of things about MiRo, including the appearance, the vocalizations, and the way MiRo behaved and responded to them.

Spearman’s rank correlation coefficient was used to assess the relationship between enjoyment and participants’ attitudes towards animals and robots. Participants’ self-rated enjoyment was strongly correlated with post-interaction (but not pre-interaction) social acceptance of robots ($r_s=0.57$, $p<0.001$) and weakly correlated with attachment to pets ($r_s=0.38$, $p=0.02$) and post-interaction likeability ($r_s=0.29$, $p=0.002$). There was also a weak negative correlation between acceptance of cruelty and enjoyment (pre: $r_s=-0.30$, $p=0.005$; post: $r_s=-0.39$, $p=0.007$).

Fig. 2 shows the total number of mentions for each animal species the participants gave in response to the question “what animal do you think MiRo is most like?” and Fig. 3 shows the mentions for themes extracted from the reasoning the participants gave to the follow-up question asking them why they thought this, grouped by animal this theme was associated with. The most commonly mentioned animal was a rabbit, followed by a dog. Post-hoc analysis using Fisher’s Exact Test showed no significant difference in species mentions between conditions ($p=0.44$). The themes that were extracted from the reasoning fell into those based on the appearance of the robotic animal and those based on the

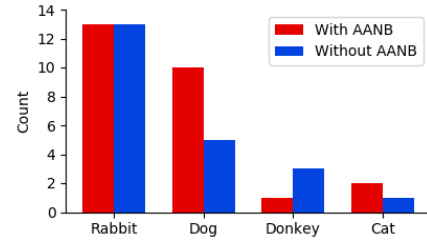


Fig. 2. Counts of animals referenced in response to “what animal do you think MiRo is most like?”

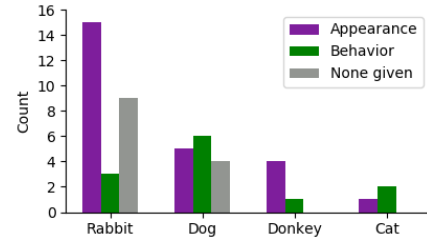


Fig. 3. Reasoning behind animal referenced in Fig. 2

behavior, e.g. references to movement, actions, or personality displayed. There was not a significant association between the species of animal and the reasoning given (Fisher’s Exact Test, $p=0.08$). However, there was a significant difference in the reasoning provided for dogs and rabbits (Fisher’s Exact Test, $p=0.048$). For participants who described MiRo as being most like a rabbit, 83% of the reasons given (56% of participants) were based on its appearance, compared to 45% of reasons for those who described MiRo as like a dog. For participants who described MiRo as being most like a dog, the most common reasoning (55% of those given, 40% of participants) was based on its behavior, whereas only 11% of participants who selected a rabbit used this reasoning. Within reasoning about appearance, the most frequent feature mentioned was the ears ($N=17$).

IV. DISCUSSION

This study aimed to investigate the potential of a robotic animal for use in animal welfare education by analysing childrens’ beliefs about its social attributes and perceived mental abilities, and acceptance of cruelty towards robotic animals. It represents a deeper investigation into the mental abilities children ascribe to a robotic animal, work that has previously been limited to humanoid robots, broken down into categories guided by work on animal consciousness. The improvement in internal consistency for several of the measures following the interaction may be an indication that children initially have a wide, inconsistent range of beliefs about robotic animals, due to them drawing on prior experience with both robots and animals in real life and media. These beliefs then seem to become more internally consistent following an experience with a specific robotic animal.

The study also showed that robotic behavior can have an impact on the mental abilities ascribed. Affective ANB not

only altered participants' ratings of emotional abilities, as might be expected, but also affected ratings of perceptual and cognitive abilities. This generalizing effect was also seen within the perceptual abilities. Three perceptive abilities were demonstrated to the children as part of the interaction session but children in the AANB condition also ascribed increased additional abilities after the interaction, namely the ability to smell and sense temperature. The three abilities were demonstrated in both conditions, but this generalizing effect was only seen in the condition with AANB. This might be because the robot in the AANB condition displayed a clear positive reaction to touch, which made its perceptual ability in that area obvious. Perceptive capabilities were also referred to in what children liked about MiRo, that MiRo could see and feel them.

The vast majority of children viewed physically harming a robotic animal as unacceptable. Furthermore, over a third of the children (17 out of 43) explained their reasoning using language that suggested they were ascribing a level of moral standing to the robotic animal and believe certain actions are cruel, going beyond viewing it as an object that it is wrong to damage. Some went further and ascribed feelings to the robotic animal or drew a specific parallel to being like humans. This is an encouraging finding for the intended use in animal welfare education, which often aims to reduce children's acceptance of cruelty to animals [27]. These results suggest we can use treatment of a robotic animal to parallel treatment of a live animal. However, one participant (in the condition without AANB) hit on a key difference between the two with the response "it's not really alive so I really don't know". This comment was consistent with the finding that those children who ascribed a level of moral standing to the robot had perceived it to be more animate than those who did not. Acceptance of cruelty was also found to negatively correlate with several post-interaction measures, most significantly likeability. Indeed, the two participants who reasoned that kicking a robotic animal was acceptable rated the robot's likeability as significantly lower than the rest of the participants (average ratings of 2.00 and 2.67 compared to $M=4.44$, $SD=0.85$). These results suggest that attributes and behaviors that increase children's perceptions of the robot's animacy and likeability may be important areas to develop before it can be used as a stand-in for a live animal in educational programmes that aim to reduce acceptance of cruelty towards animals.

As shown in Fig. 3, children compared MiRo to a range of different animals. The reasoning given fell into two categories: appearance and behavior. When children referenced two different animals they commonly identified a clash between these two aspects, e.g. "[MiRo] looks like a bunny and acts like a dog". This reasoning from a participant was generally indicative of the animals and reasoning used by many participants, that the robot had the appearance of a rabbit and the behavior of a dog. None of the children in the study owned a rabbit, so this judgment may also have been made due to a lack of awareness about rabbit behavior and a familiarity with dog behavior. The aspect of appearance

that received the most mentions was the ears ($N=17$), though children still drew different conclusions about the animal represented, comparing them to rabbits, donkeys, and cats. This highlights the challenge of using non-specific zoomorphic robots for animal welfare education as children may be drawing upon a wide range of animals in their interactions. The Scottish SPCA recommends that educational programmes are designed to target specific animals since, for example, a rabbit has different care needs to a dog. All the animals the children referenced are mammals, so an appropriately designed programme could discuss requirements common to most mammals. Alternatively, minor adjustments could be made to the robot, such as swapping out accessories, to encourage children to view the robot as a specific animal. In this way, the versatility in schema applied to non-specific zoomorphic robots could be leveraged for their use in AWE.

There were fewer significant differences than expected between the condition with AANB and the one without. The AANB, while appropriate for an animal, was subtle and may not have been picked up on by children, particularly those who did not engage in tactile interaction with the robot (an interaction method that rapidly improved the robot's mood and resulted in affective displays). Future work could look at this with a within-subjects design so participants could experience and compare both versions, or compare the perceptions of a group of participants who had been educated regarding animallike affective non-verbal behavior and a control group.

V. CONCLUSION

Overall, this study has shown the potential for zoomorphic robots like MiRo to be used in animal welfare education with primary-aged schoolchildren. Participants' beliefs about the robotic animal's mental abilities showed similarities with those of animals and were positively impacted by robotic displays of affective animallike non-verbal behavior. Results from analysis of participants' acceptance of cruelty towards the robotic animal suggested a parallel could be drawn with live animals if the children perceived the robot as sufficiently animate. Additionally, the participants largely evaluated the interaction positively and the majority agreed or strongly agreed they would interact with the robot again which suggests the robot could succeed at being an engaging and effective tool for educating children about animal welfare.

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