Dogs or Robots: Why do Children see them as Robotic Pets rather than Canine Machines?

B. Bartlett* **V. Estivill-Castro†** **S. Seymon†**

*School of Cognition, Language and Special Education
Griffith University
Brisbane 4111 QLD Australia
Email: `b.bartlett@mailbox.gu.edu.au`

†School of Computing and Information Technology
Griffith University
Brisbane 4111 QLD Australia
Email: `v.estivill-castro@griffith.edu.au`
Email: `Stuart.Seymon@student.gu.edu.au`

Abstract

In the not too distant future Intelligent Creatures (robots, smart devices, smart vehicles, smart buildings, etc) will share the everyday living environment of human beings. It is important then to analyze the attitudes humans are to adopt for interaction with morphologically different devices, based on their appearance and behavior. In particular, these devices will become multi-modal interfaces, with computers or networks of computers, for a large and complex universe of applications. Our results show that children are quickly attached to the word 'dog' reflecting a conceptualization that robots that look like dogs (in particular SONY Aibo) are closer to living dogs than they are to other devices. By contrast, adults perceive Aibo as having stronger similarities to machines than to dogs (reflected by definitions of robot). Illustration of the characteristics structured in the definition of robot are insufficient to convince children Aibo is closer to a machine than to a dog.

Keywords: robots, multi-modal interfaces, human attitudes, zoo-morphological autonomous mobile robots.

1 Introduction

The play *R. U. R. (Rossum's Universal Robots)*, written by the Czech author Karel Capek, was produced in London in 1923. The term robot entered the English language (in Czech the word 'robota' means 'heavy labor'). The robot concept remained science fiction until 1961 when Unimation Inc. installed the world's first industrial robot in the US. Unimation Inc. made Australia's first robot, installed in 1974. The emergence of legged autonomous robots and their commercial release (as in Honda's Asimo and Sony's Aibo) contribute to support the hypothesis that mobile robots will soon become common in our everyday environments. The commercial release of the Personal Computer (PC) occurred just a generation ago, yet now it is a common household item. This forecast has prompted some studies into the acceptability and attitudes these artifacts generate among human beings (Fong, Nourbakhsh & Dautenhahn 2003). For example, Kahn *et al* have recently embarked on a series of studies with children (Kahn Jr., Friedman, Freier & Severson 2003) and adults (Kahn Jr., Friedman & Hagman 2002) investigating matters such as humans attributing social and ethical stance to robots like Sony's Aibo. Earlier Bumby and Dautenhahn (Bumby & Dautenhahn 1999) explored reactions of children as they interacted with a robot. Reports have recently appeared in the media of cases where humans also build emotional attachments to robots that do not look like animals, similar to those they have for home pets. An example is the robotic vacuum cleaners in (Kahney 2003).

While some experts in childhood development argue that the use of robot-dolls (machines with realism) in children's environments 'cuts off open-ended imaginative play' there are some studies showing that intelligent children will still explore beyond the limitations of the machine. Similar concerns about other technologies have been also subject of debate. For example, the concerns about children reducing their play with other children, or increasingly aggressive behavior because of computer games, can be attributed more to exposure to the type of game than to the technology of computer games themselves (Lawry, Upitis, Klawe, Anderson, Inkpen, Ndunda, Hsu, Leroux & Sedighian 1995). Researchers have found that children (in particular boys) will entertain and seek more challenging and interesting computer games (not necessarily violent games) and that there is no observable increase in violent behavior or deterioration in social behavior (Lawry et al. 1995).

Recent studies have focused on the attitudes generated by Sony's Aibo on humans, we propose here to explore the differences between DOG (as in living animal) and ROBOT (as in lifeless machine assembled from parts) in the concepts and language formations in children. Naturally, the smaller the difference, the more it is likely that humans will attribute animal characteristics (as high up as rights) to a robot. The question is, 'what makes a small or a large difference?'

If the difference is very small, perhaps humans will interact with autonomous robots as they do with animals. We suggest that in today's children's world, the issue is not confusion between reality and fantasy (Aylett 2002). To a child, Sony's Aibo is not a fantasy but reality.

Identification of what makes children perceive a robot as a dog (an animal) or as a robot is important, especially if one wants to design robots stressing the difference or diluting it. Our research reveals that the look and feel of Sony's Aibo and its body shape go a long way into its acceptability as a dog. Its play-

This work was supported by a Griffith University Research Grant as part of the project "Robots to guide the blind - the application of physical collaborative autonomous intelligent agents".

ful behavior, tail wagging, legged walk, recovery from falls, sitting and hand shaking are absorbed into the child's mind. Later, illustration of its robotic features are repeatedly insufficient to fully convince the children that this is an artifact (and not a being with feelings).

Unless Aibo does something unacceptable for a dog (like speak with a human voice), it remains essentially a dog. Our findings that human speech in Aibo reduces its dog-ness and increases its robot-ness may be attributed to the 'uncanny valley' (Scheeff, Pinto, Rahardja, Snibbe & Tow 2000). Although we are not measuring emotional response, we have observed dissatisfaction with Aibo as a dog, since clearly it is only humans that talk (although children accept talking toys and talking animals in fantasy or animated movies).

The rest of this paper is organized as follows. Section 2 will describe our research methods. Section 3 will elaborate on the findings. Section 4 will present conclusions and final remarks. Our aim is to explore and contrast the properties currently accepted in the definition of 'mobile autonomous robot'. The International Federation of Robotics (IFR) and the Australian Robot Association follow the ISO standard vocabulary (ISO 8373) to describe 'manipulating industrial robots operated in a manufacturing environment'. A robot has three essential characteristics:

1. It possesses some form of mobility (formally, a robot must possess at least three programmable axes of motion).
2. It can be programmed to accomplish a large variety of tasks.
3. After being programmed, it operates automatically.

Mobile robots can move away from a fixed location and come in two varieties: *tethered* and *autonomous*; a tethered robot may have its power supply or its control unit overboard, possibly relying on a desktop computer and a wall outlet and a long cord. Autonomous mobile robots bring everything along (control unit, body, actuators, sensors and power supply). The control unit is typically a computer and software. Our research attempts to find out if children do indeed notice these properties or fixate more on the form and behavior of the artifact.

2 The methods

This research was performed by a series of demonstrations of Aibo and other robots, toys and models. in particular using Lego Mindstorms[1] constructions (Knudsen 1999), remote control toy cars and autonomous battery toys.

The demonstrations were conducted with preschool children as well as those from the first 4 years of primary school across 3 schools, two childcare centers, and a museum in the urban area of Brisbane, Australia. Table 1 summarizes the presentations and the age groups of children. Whenever consent was given, a video/or audio of the session was recorded. Alternatively, a secretary took notes of the statement made by children. Sessions lasted between 30 minutes and approximately one hour.

The sessions consisted of five stages.

1. *Establishing the language.* In the first minutes of the session, children are asked to describe what they see. The goal of this stage is to obtain a vocabulary from the children to discuss the artifacts that will be presented later.
2. *Demonstration of Aibo.* In the next 5 to 7 minutes, a demonstration of Aibo is performed with one black model without a memory stick, so the default simple 'dog-like' behaviors are in place.
3. *Demonstration of the concept of robot.* This stage illustrates the main features that are common in accepted definitions of a robot. It also ensures that the children observe that Sony's Aibo shares these properties with robots.
4. *Investigate animal attributes on Aibo.* This stage questions the children for the existence of animal properties on Sony's Aibo and the justification for their belief.
5. *Challenge Aibo's animal attributes with the other artifacts used in the session.* Children are asked to confirm or justify that Aibo is a robot. Attempts are made to convince them of the artificial nature of Aibo by showing the same property in an artifact accepted as lifeless and to compel them to decide on one side of the Dog vs Robot debate (or generate a new term to describe it).

The initial phase starts with the projection of a video from RoboCup-2002 legged league (Veloso, Uther, Fujita, Asada & Kitano 1998) (the video is the match between the University of Newcastle and Team Sweden). Presentations at the Powerhouse Museum in Brisbane consisted of a live match with 8 dogs programmed as the Mi-PAL Team Griffith participation in RoboCup-2003. After two minutes the children are asked to describe what they see in the video. In the video, human manipulators are visible, which contributes to the realization that these are real things and not an animation film. Children are requested to indicate what the 'dogs' are doing (if they suggested this word, but if they suggest 'puppies' then 'puppies' is used). That is, we use the same words the children themselves have introduced to describe what they see.

Children are then asked to justify why it is a game of 'soccer/rugby' (or whatever word was the most common or immediate reply).

The phase finishes by bringing an Aibo that is switched off, placing it on the ground, turning it on, and waiting. Since Aibo requires some seconds to 'boot' we observe children's reactions and comments. This phase is obviously different for blind children. It is replaced by allowing children to explore the robot with their hands. Blind children still find and recognize legs, paws, ears, head and tail because of shape, texture, malleability and movement.

We then proceed to phase two where we illustrate the default behavior of the Aibo, which includes the following interactions.

- A couple of fast strokes on its back starts it on a walk while it makes the sounds of a marching tune.
- Hard strokes on its head produce sounds and a red light on its head LEDs.
- Soft strokes on its head produce sounds and a green light on its LEDs.
- Scratching under its chin produces another set of sounds and lights.
- Placing it on the floor on its side produces some sounds, and then Aibo performs a routine to stand back on its four legs. After getting up, Aibo shakes, wagging his tail and making other sounds.
- Presenting a pink ball produces sounds and the LED on its tail to go pink.

[1] A trademark of the LEGO group.

School	Level	Children's age	Group size
Boronia Childcare Center	pre-school	4-5	10
Carole Park State School	pre-school	4-5	17
Holland Park State School	3rd year primary	7-8	25
Holland Park State School	1st year primary	5-6	24
Camp Hill State School	1st year primary	5-6	10
Camp Hill State School	1st year primary	5-6	12
Camp Hill State School	1st year primary	5-6	11
Carole Park State School	1st year primary	5-6	22
Carole Park State School	2nd year primary	6-7	24
Carole Park State School	2nd year primary	6-7	28
Carole Park State School	3rd year primary	7-8	26
Carole Park State School	4th year primary	8-9	20
Powerhouse Museum	pre-school	4-5	10
Narbethong State Special School	pre-school (blind)	4-5	3

Table 1: Presentations conducted and age groups.

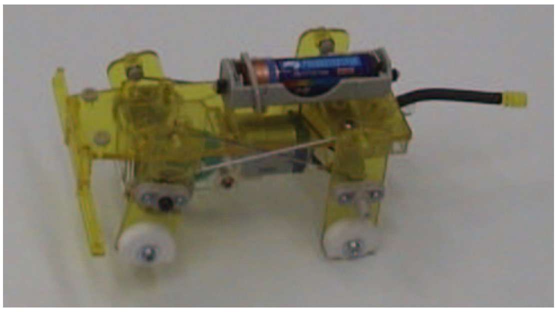


Figure 1: A 4-legged walking toy with visible battery, motor and gears. A flexible tail resembles a dog tail.

Figure 2: A model of a humanoid robot.

- Other behaviors that Aibo produces are not directly triggered by the manipulator. These include Aibo sitting down, Aibo lying on his stomach and waving all fours as a synchronized dance, Aibo waiving one leg, Aibo moving his head from side to side and flapping his ears.

Children are then invited to interact with Aibo directly. In particular, to show the pink ball, to produce the green lights or invite him to walk. They are also invited to explain what Aibo is doing in their own words. There are a series of questions that the presenter goes through as the illustration of behaviors is performed. These questions are as follows:

- What is Aibo doing now?
- Is he happy or is he sad?
- Does he like to be touched like this?
- Do you think he can get up by himself?

At the completion of this phase, Aibo is turned off and focus is transferred to other examples of robotics. Because the commonly accepted definitions of mobile robots includes that they have their own control unit, phase three consists of the following:

- A presentation of a 4-legged toy with a tail (made of a spring) that has a visible battery, motor and gears (Figure 1). It is illustrated that this toy needs a battery to operate it and that it has an on-off-reverse button. Children are asked to carry out the task of setting it off or stopping it by taking the battery out. This illustrates that mobile autonomous robots require power and carry their source of power.

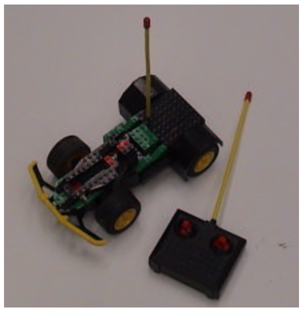


Figure 3: Remote control car to contrast with the notion of autonomous control.

- A presentation of a model of a humanoid robot (Figure 2). Although it looks like a robot, it can be seen that it has no motors, no batteries and essentially does nothing.
- A presentation of a remote control car (radio controlled) (Figure 3). This car is also shown to have batteries on board but all behavior is derived from the actions on the two-lever remote control. The first lever produces forward or reverse motion on the back wheels and the second lever produces left/right turns on the front wheels. This illustrates the notion of control (remote and human).
- A Lego Mindstorm construction extremely similar to 'Hank the Bumper Tank' (Knudsen 1999) (Figure 4). This robot is shown to have a behavior that allows it to move around and steer away from obstacles it bumps into (the program is very similar to the one suggested in (Knudsen 1999, Chapter 2)). As part of the interactive nature of the presentation, the children are asked to act

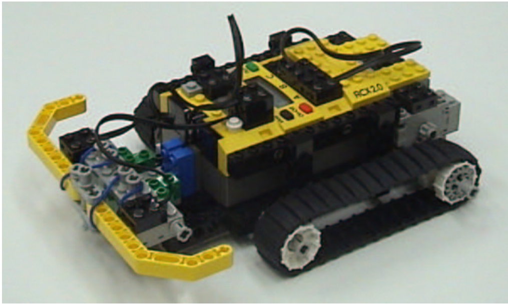


Figure 4: A Mindstorm construction with touch and light sensor.

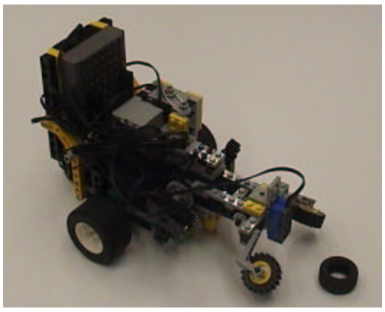


Figure 5: A Mindstorm construction with touch and light sensor, that acts on its environment with a mechanical arm, and plays sounds.

as obstacles for 'adapted' Hank. The presenter points out the sensors behind the robots bumper, and illustrates that disconnecting these sensors makes it 'unaware' of obstacles.

We also added to Hank a program that used a light sensor to monitor the color of the ground beneath it. This program was similar to the obstacle avoidance previously mentioned, but rather than avoid objects it would move away from dark areas. We presented this behavior as 'being afraid of the dark'. By switching between these modes, we illustrate that the behavior of the robot changes with the chosen program.

Using Lego's ROBO-Lab (a graphical programming application) to build a very simple program that makes Hank spin in a circle for four seconds, we show the children its programmable nature. The children are taken through the process of building the program, transferring it onto Hank via an infrared interface and finally running it. When the program is running, the children are encouraged to count along, thus verifying that the program is indeed the one just built. This is repeated for at least two other timings (around 10 to 20 seconds).

- A Lego construction extremely similar to Minerva (Knudsen 1999, Chapter 6) was presented next (Figure 5). The components were shown to be the same as Hank's and the Lego RCX is labeled as the 'computer control'. A program similar to the one suggested (Knudsen 1999) produces the behavior illustrated to the children. Minerva moves around a white floor until it finds a black object, uses a robotic arm to pick it up, then turns around and brings it to another position close to where it started. It then releases the object and plays a tune. The presenter ensured that the children observed that Minerva perceives its environment and can act to change it (thus the notion of actuator is illustrated).

- A series of pictures (or videos) of autonomous robots were shown to the children. These images demonstrate that robots come in all sorts of shapes and sizes. Among these are pictures of more Aibos, Honda ASIMO, the Sony humanoid SDX, MINERVA (Thrun, Bennewitz, Burgard, Cremers, Dellaert, Fox, Hahnel, Rosenberg, Roy, Schulte & Schulz 1999) and Kismet (Brooks 2002). It was pointed out that robots can produce smiles, walk, and be as small as a cockroach. Pictures of experimental robots were shown to display the wires, gears and components inside their packaging.

Aibo was then brought back as the presenter repeated the main concepts, namely:

Aibo requires power and carries a battery. Aibo is turned on and off. Also, it is shown that Aibo's behaviors are interrupted and stopped if the battery is removed.

Aibo has motors. The gears on Aibo's joints, and wires near its neck are pointed out to the children.

Aibo has sensors. The strokes on head and sensitivity to the pink ball are illustrated once more. Using another pink object (perhaps a piece of clothing, or the memory stick of Aibo), we show that the behavior is triggered by the color being noticed by a sensor and not Aibo understanding the concept of a ball.

Aibo has actuators and a control program. We install a memory stick and re-start Aibo. With the new program it kicks a ball as in the RoboCup video. We illustrate Aibo's behavior changes with different memory sticks.

Once this is completed the next phase commences by the presenter asking one of the following questions.

1. Does Aibo have feelings?
2. Where does Aibo get energy from?
3. Will Aibo have babies?

Responses of several children were collected. We expected that this question would have distinct answers depending on whether we were referring to a robot or a 'living' dog.

We then passed to the final stage. Each time a child made a response that seemed to indicate animal essence or animal agency in the Aibo, we challenged the response. For example, if a child indicated that Aibo had feelings, we next asked what the child thinks happens to the feelings when Aibo is turned off. We found children would continue to support their point of view. Following the previous example, many children followed the path that Aibo was just asleep when turned off. The challenge continued as the presenter requested children to explain what sort of feelings Aibo has or if the feelings fade when the battery runs out. Also, the presenter checked if the other artifacts, shown before, have feelings and asked the children to explain why the others do or do not have those or other feelings.

The sequence of challenges for the 3 questions above were as follows.

1. Does Aibo have feelings?
    - What happens to Aibo's feelings when he is turned off?

Figure 6: The demonstrator with a class of grade 2 children and 3 of the objects: Aibo, Hank and the 4-legged walking toy.

- What happens to his feelings when the battery runs out?
- What happens to his feelings if we remove/change/replace the memory stick and Aibo's personality changes?
- What happens to his feelings if Aibo is broken? Will the feelings come back if we glue him?
- What feelings do you know Aibo has? How do you know he is happy/sad?
- Is it possible to pretend to be happy but not be happy? Do you think Aibo is happy or just pretending?

2. Where does Aibo get his energy from?
   - Where do you get your energy from?
   - Where do the other artifacts get their energy from?
   - Does Aibo work without a battery? Do the others work without a battery?
   - What do you think Aibo eats/drinks? Do you think he needs to visit the toilet?

3. Will Aibo have babies?
   - Is Aibo a baby dog? How do you know?
   - How will Aibo look after (care for) the babies?
   - Does Aibo need to charge/replace the battery of the babies?

These paths of questioning were not all developed ahead of the first presentation. They evolved from one presentation to the next. Their length reflects the resistance of the children to change their opinion, even if all other artifacts have opposite responses to these questions. That is, for each question, before we progressed to the next, we confirmed that the children sustained the notion that a difference remains between Aibo and the other artifacts. For example, in the last question sequence, children would start by confirming that none of the other artifacts can have babies while Aibo can. When progressing to 'Is Aibo a baby?' and contrasting this with 'Is Hank a baby?', most children realized that Aibo is really like Hank and cannot have babies.

3 The findings

After an analysis of the transcript of our videos and notes we summarize the following findings. It is remarkable that when we queried the children for their first impressions of the video we obtained the following results. To the question 'What do you see?' all sessions had children responding that they saw 'dogs'. This is surprising for two main reasons: firstly the video shows the robots playing soccer, a behavior not commonly attributed to dogs. And secondly, the children would have anticipated seeing robots through prior conversations with parents and teachers. This may explain why a few children claimed that the adults in the video where robots.

As the age of the pupils involved in the study increased, we noticed that the tendency to regard the robots as 'dogs' decreased. The more mature respondents were more likely to label the robots as 'robots' or 'robotic dogs'. One pupil also gave the more generic answer of 'animals', and another thought that they were 'cats'. Interestingly, on a few occasions children referred to the humans in the video as the robots. We believe this is due to their anticipation to see robots and perhaps the media culture of humanoid robots.

To the question, 'What are they doing?' most children identified the activity as a game of 'soccer'. This is surprising, since the RoboCup has barriers around the pitch that make the game more similar to ice-hockey, and although the robots are legged, they do not kick the ball with one leg. All robots in this video kick the ball with two legs simultaneously or head-butt the ball. The ball is also bright orange, clearly not a soccer ball. Another point is that although played in Australia, it is not the most commonly played sport.

Other suggestions included, 'they're fighting', 'playing hockey', and one child thought he was watching a game of tennis.

Justifications for 'why is it a game of soccer/football?' included a rounded ball on the ground, goals, two teams, referees and goalies.

When initially presenting the Aibo to the children, rather than give it the label 'it', we found that they would usually use 'him' or 'her'. Once again this was more pronounced with younger subjects. As the presenter went on to explain the attributes of the Aibo and show its operation, the children while probing with questions would begin to lose the gender label.

The children generally were of the opinion that the Aibo did have emotions, with a couple of them claiming that this was so because it had a 'mind'. This opinion was seemingly an accepted one with many children declaring at certain stages of the proceedings that it was either happy or sad.

Upon the exhibition of other robots and robot-like artifacts, the general consensus was that the Aibo did in fact meet the criteria for being a robot. However, the most common term used to describe it was that of 'robotic dog', where dog is the noun. This emphasis on the dog nature of the robot suggests that the subjects were still willing to consider it animal-like.

The youngest group, however, needed the most convincing. They insisted that the Aibo was a dog, even after repeated demonstrations of its robotic nature, with the presenter even stating in no uncertain terms that it was a robot. They did come around eventually, with one child using the 'robotic dog' description, and his peers following suit.

We briefly describe some reaction to the other objects. Although initially enthusiastic, children were quickly disappointed by the model of the humanoid; mainly its inaction made it uninteresting. One child said, "it's just a toy, not a robot". The 4-legged walking toy caused some laughs because it bumps into things, but children realized rapidly that it did not offer any 'interesting' interaction beside turning it on and off (potentially reversing the direction). The remote control car was appealing and children wanted to play with it even after the presentation. It was clear to them they were controlling it. Hank did cause surprise and children wanted to continue playing with it, or asked about how to program it. Children wanted to interact with it and explored different obstacles for its obstacle-backing behavior. On two occasions we witnessed children convinced that Hank also had feelings because it was “afraid of the dark”. The mechanical-arm robot caused amazement. We believe this greater surprise was because children familiar with Lego do not expect the action of a mechanical arm lifting an object.

We also performed a variation in our initial approach to confirm some of these findings. We approached a different grade 6 class (12 year-olds) that had been already working with Mindstorm robots and had done some research assignments on the Internet and in the library on topics such as ‘What is a robot?’. We did a presentation in which the objects were not necessarily the focus, but the properties of a robot were the focus. We also demonstrated different applications of robotics, like using Miranda to assist a blind person to read a WEB page. The method for collecting the children’s attitudes was a questionnaire of 25 questions asking children to choose between two positions and to give their reasons for such decisions. We invited them to reflect on their responses, so they were asked to answer the questions over a day at school and at home. The results of 23 answered questionnaires confirmed that a dog-looking robot rapidly acquires animalistic properties and values in the minds of children. In particular, 75% of the children confirmed that Miranda should be called a ‘robotic dog’ rather than a ‘dog-looking robot’. Note that the preferred noun is dog over robot. The reasons provided in the questionnaire are illustrative of their thinking: “It has more dog features than robot features”, “Miranda has characteristics a dog has”, “Kinda looks like a real dog” “It is an automatic dog” and “Just doesn’t look like a dog, she has a dog personality”. And on the question “Does Miranda have feelings?” again 75% responded positively. Some of the reasons were “She just isn’t a robot. She’s almost a real dog”, “She can be happy, unhappy”, If you hit her hard, she would make a noise, but she felt it”. Note that in this presentation we actually changed programs several times, radically changing the behaviors and personality of Miranda. Also, real dogs do not talk, but our programs had a female voice for instructions to kick a ball and a male voice reading Web pages. Only one child classified Miranda as a robot because dogs do not sing.

4 Discussion and Final Remarks

The blurring of the concept of robotic pet or canine machine is of interest to us because of the direct applications of autonomous mobile robots in helping people. In particular, we foresee that people with disabilities, the elderly and other groups in need of assistance, are the first humans that will benefit from autonomous mobile robots. Naturally, the attitudes, acceptability and adequate expectations are to match an effective human-computer interaction. If the person expects smarter behavior of the robot (things like gesture/voice recognition) and the technology does not deliver, then rather than assisting, we will frustrate the person. It is also important that anyone who encounters a person assisted by a robot approaches with attitudes and gestures that allow the robotic assistant to facilitate the approach. The main motivation behind this research is a related project on using Aibo to assist blind people. While it may seem straightforward that a robotic assistant for the vision impaired person should be shaped as a dog, this is not so. Even with guide dogs, other humans find it difficult to approach and assist a blind person. Humans expect a strong bond and loyalty of the animal to its owner, fearing that dogs may misinterpret help as interfering with the bond, causing then to react violently.

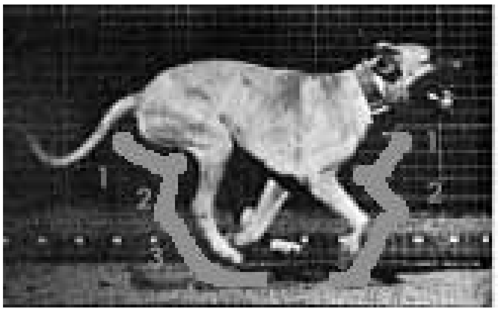
Our findings agree with those of others (Kahn Jr. et al. 2002) in that there is a progression of attributes that humans ascribe to robots like Aibo. This progression starts from Essence, and advances to Agency, Social Standing and Moral Standing. Our findings are that Aibo fulfills biological animistic underpinnings (children refer to its tail, legs, ears and behaviors in the same way as for living dogs). It also fulfills Agency properties (children attribute intentions, feelings, emotional states, wishes, desires, goals).

We left aside social standing in our methodology, but strongly suspect that children attribute an emotional connection and companionship to Aibo. We observed a clear preference among children for ‘Do you want to pat the dog/puppy?’ over ‘Do you want to touch the robot?’. Many children made unsolicited comments about how similar it was playing with Aibo to playing with their dog at home. Similarly, we refrained from exploring children’s attribution of moral standing to Aibo (for example, should Aibo be punished for doing something wrong). Nevertheless, we received unsolicited suggestions that ‘leaving Aibo alone or not playing with him would make him sad’ and that ‘batteries should always be charged, which may mean more responsibility than for a living dog’. These types of comments do attribute some rights to Aibo and a sense that it also deserves some respect.

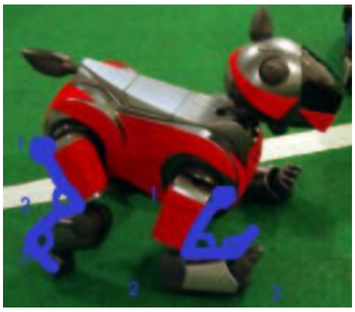
Our observations indicate that Essence and Agency are maintained in the child’s beliefs even in the presence and practical illustration of other machines for which they will not typically attach such biological or animistic properties, nor psychological characteristics (although Bob the Builder’s cars and machines talk). In fact, we witnessed arguments and debates among the children which turned the balance the other way around, some managing to convince others that Hank had feelings like ‘being afraid of the dark, because *afraid* is a feeling’.

Also, we found observations that concur with the writing of anthropologist S. Turkle (Turkle 1999). In particular, although we did not intend to observe adults, we witnessed parents and teachers attempting to convince the children that Aibo was a machine and not a dog. Some child-carers seem to interpret our experiment as a lecture on the living versus the non-living. We believe this reflected some of Turkle’s conclusions about the ‘thinking about aliveness’ with older people interpreting machines and computers through mechanistic/physical interpretations while the newer generation interprets beings in computer games and robots as ‘sort of alive’. Our best example of this was witnessing a parent selecting a particular physical argument to convince her 5-year old of ‘the clear difference’ why Aibo is not a dog. This also pointed out a difference between Aibo and dogs that we had not observed but that the adult believed made “the difference”. We attempt to illustrate it with Figure 7. Aibo has one less joint in the back leg than a dog (the dog, as shown in Figure 7(a), has hip (1), knee (2), ankle (3) and toes (4)). This is one degree of freedom less and also the toes bend back in the dog, while they do not on Aibo. Note that if we were to choose a physical argument it is perhaps more obvious that Aibo does not have two eyes or does not have a wet nose. The point is that a basic minimum of physical structure is enough to engage children in a psychological/conceptual interpretation that then is hard to remove on the basis of physical evidence.

We believe our results indicate that children are



(a)



(b)

Figure 7: A dog (a) has one more degree of freedom per leg than Aibo (b) and has more movement in the toes than Aibo.

quickly attached to the notion that 'robotic dogs' are closer to living dogs. Although we would not go as far as S. Turkle to suggest that 'living' has a new meaning for this generation of children, we suggest that they will see them as robotic pets more than canine machines. We expect, therefore, that in the future, humans will adopt more of them as an interface for human-computer interaction.

Prof. B. Shneiderman is probably the world's leading authority in Human-Computer Interaction. He has repeatedly been outspoken about reducing 'machine intelligence' and 'software agents' for building computers that are more effective tools (Beardsley 1999). At first, our research seems to contradict some of his ideas; but, interaction with a robot is interaction with a computer and we agree that it allows for direct manipulation, even more realistic and perhaps more meaningful than on the computer screen. Also, it is now clear that domestic robots will soon be around us and computers will not be restricted to output devices like monitors, nor will computers be confined to fixed locations. Third, we argue that studies such as ours advance the possibilities of having a 'controllable, consistent and predictable interaction' with a robot. Thus, we share the vision of interaction facilitated by proper design. Finally, our aim is interaction with people who are blind. In such case, visualization (the coloring of pixels in a monitor) for 'insight' cannot be used. Shneiderman also agrees on this point. We argue that properly designed robots will offer a multi-modal interface where insight is communicated by embodiment and movement as well as sound.

Other papers in the literature confirm that people may develop strong attachments, and even affectionate relationships with artificial information systems. Those studies involve human adults on one side and rather simple emulations of human intelligence in the other. In such cases, the interface has been rather simple (or at least not multi-modal), like through a phone conversation. It is interesting that this may have both positive and negative outcomes. For example, as reported in the case of a 'Health Behavior Advisor System' (Kaplan, Farzanfar & Friedman 1999), some patients felt motivated to follow a healthier life style, while others found it inflicted a sense of guilt that did not motivate healthier habits. We believe that understanding people's expectations for robots is important since these expectations will define the context for the interactions that may result in effective use of robotic technology. An example is the potential attribution of moral standing to robots. This could eventually regard the robot (and not its manufacturer) as responsible for its actions. Certainly, this would have many implications for our society.

5 Acknowledgments

The authors wish to thank the anonymous referees for the constructive feedback provided in their reviews. This work was supported by a Griffith University Research Grant as part of the project "Robots to guide the blind - the application of physical collaborative autonomous intelligent agents".

References

Aylett, B. (2002), *ROBOTS — Bringing intelligent machines to life?*, ABC Books, Sydney NSW, Australia.

Beardsley, T. (1999), 'Humans unite!', *Scientific American* **March**, 35–36. Profile Column.

Brooks, R. (2002), 'Humanoid robots', *Communications of the ACM* **45**(3), 33–38.

Bumby, K. & Dautenhahn, K. (1999), Investigating children's attitudes towards robots: A case study, *in* 'Proceedings of the Third Cognitive Technology Conference, CT'99', M.I.N.D. Lab, Michigan State University, East Lansing, MI., pp. 391–410.

Fong, T., Nourbakhsh, I. & Dautenhahn, K. (2003), 'A survey of socially interactive robots', *Robotics and Autonomous Systems* **42**, 235–243.

Kahn Jr., P., Friedman, B. & Hagman, J. (2002), I care about him as a pal: Conceptions of robotic pets in online Aibo discussion forum, *in* 'Proceedings of CHI, Interactive Poster: Fun changing the world, changing ourselves', pp. 632–633.

Kahn Jr., P. J., Friedman, B., Freier, N. & Severson, R. (2003), Coding manual for children's interactions with Aibo, the robotic dog — the preschool study, Technical Report UW CSE 03-04-03, Department of Computer Science and Engineering, University of Washington, Seattle, US.

Kahney, L. (2003), 'The new pet craze: Robovacs', Wired Magazine. June, 16th; visited Septenber 10th, 2003, www.wired.com/news/technology/0,1282,59249,00.html.

Kaplan, B., Farzanfar, R. & Friedman, R. (1999), Ethnographic interviews to elicit patients, reactions to an intelligent interactive telephone health behavior advisor system, *in* M. N.M. Lorenzi, Bethesda, ed., 'Proceedings: AMIA Symposiu', American Medical Informatics Association, www.amia.org/pubs/symposia/D005604.PDF.

Knudsen, J. (1999), *The Unofficial Guide to LEGO MINDSTORM Robots*, O'Reilly, Sebastopol, CA.

Lawry, J., Upitis, R., Klawe, M., Anderson, A., Inkpen, K., Ndunda, M., Hsu, D., Leroux, S. & Sedighian, K. (1995), 'Exploring common conceptions about boys and electronic games', *Journal of Computer in Math and Science Teaching* **14**(4), 439–459.

Scheeff, M., Pinto, J., Rahardja, K., Snibbe, S. & Tow, R. (2000), Experiences with Sparky: A social robot, *in* 'Proceedings of the Workshop on Interactive Robot Entertainment'.

Thrun, S., Bennewitz, M., Burgard, W., Cremers, A., Dellaert, F., Fox, D., Hahnel, D., Rosenberg, C., Roy, N., Schulte, J. & Schulz, D. (1999), MINERVA: A tour-guide robot that learns, *in* 'KI - Kunstliche Intelligenz', pp. 14–26.

Turkle, S. (1999), What are we thinking about when we are thinking about computers?, *in* M. Biagioli, ed., 'The Science Studies Reader', Routledge, New York.

Veloso, M., Uther, W., Fujita, M., Asada, M. & Kitano, H. (1998), Playing soccer with legged robots, *in* 'In Proceedings of IROS-98, Intelligent Robots and Systems Conference', Victoria, Canada.