Aesthetics of a Robot: Case study on AIBO Dog Robots for Buddy-ing Devices

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ABSTRACT: *The more embedded and ubiquitous computing devices are introduced in everyday domestic applications, the more important the aesthetics of interfaces become. In this paper, our interest is the aesthetics of domestic robots as an example of buddy-ing physical devices. We report on observations of using Sony AIBO dogs in outreach programs to new and untraditional user groups. The sessions were part of Narrative Lab workshops and Institute of Creative Technology (IOCT) Salon workshops. In the case of Narrative Lab workshop, AIBO robots were introduced to writers who were exploring new means of inspiration and writing in new media. A more elaborate study was conducted with undergraduate Humanities students. The observations in this paper will focus on the reactions towards the dog look and behaviour. It explores the relationships between the behaviours demonstrated, the physical appearance of the robot, and the users' perceptions. We call upon aesthetics theories, aesthetics of interfaces, aesthetic metrics, and art theories research in our analysis of these observations. The outcome will be in the form of* a *framework to assess physical domestic devices design for buddy-ing interaction leading to design guidelines.*

Keywords: Aesthetics of Physical Devices, Human-Computer Interaction, Domestic Devices, Buddy-ing Devices, Aesthetics of Interaction, Metrics

Received: 11 November 2013, Revised 17 December 2013, Accepted 24 December 2013

1. Introduction

In developing buddy-ing devices such as educational robots or mobile devices for social uses, the look and feel of the device is almost as important as its functions especially in the case of domestic devices and entertainment computing. In this paper, we study the impact of the aesthetics of device appearance on the user perception, appreciation and acceptance of the device as a buddy rather than pure technological wonder. To conduct this study Sony AIBO robots were used with groups of technology users within the context of writing as a creative process.

This study can be generalised to other contexts and for the purposes of interface design for physical devices and software applications. The conclusions are abstracted in a metrics framework to assess the design of buddy-ing devices and interfaces; in other words, the conclusions provide a framework for analysing the aesthetics of interaction.

The paper starts with a preliminary look at the subject of interface aesthetics and its relevance. It also provides the motivation to the work reported. The main part of the paper is concerned with the experiments conducted. These experiments were based

on the use of AIBO robots in different settings within the context of creative writing and narrative. The users, who are non-technologists, explored the interaction features of the robots in these different settings and reported back on their impressions. These are analysed in relation to each experiment and summarised in section 3.6. The paper then concludes in section 4 with a proposed metrics framework for guiding and assessing the design of buddy-ing devices. This metrics framework is then demonstrated in section 5 through a comparative case study between AIBO dogs and iCat.

2. Background: Preliminaries and Motivations

2.1 Motivation

Sony Artificial Intelligence Bots (AIBOs), figure 1, are an example of realising the aim of creating a buddy robot through a pet dog, and in this situation it should be noted that the appearance of the robo-pet is as important as the behaviour.

Figure 1. Sony AIBO robot on an outing

The multi-modal expression of thoughts and emotions [5][1] play a big role in interactivity. To explore impact of look-behaviour on the users we needed a medium of communication. Narratives seemed a good approach that is far less compartmentalized than traditional software engineering approaches. Thus a team was put together with credentials in artificial intelligence and creative writing. The aesthetical analysis of narratives provided by participants was hoped to provide an insight into how the object is perceived aesthetically.

The experiments were conducted by a transdisciplinary group based at the Institute of Creative Technologies (IOCT), De Montfort University. The IOCT comprises an interdisciplinary laboratory and houses a number of key projects, all of which cross the traditional disciplines. Thus it offered an ideal environment to conduct the planned experiments.

The experiments included the introduction of an AIBO dog into a working office environment where colleagues could supervise and manage the robot as they felt appropriate. They were also used in two creative writing workshops, one with first year undergraduates, and another with members of the public. The resulting interactions generated a number of narratives in which the participants related accounts of ways in which they had interacted with the AIBOs. Our interest within this paper is to examine what can be learned from these 'AIBO Stories' in relation to the creation of an aesthetically acceptable buddy-ing device?

[1]Also see iCat project http://www.hitech-projects.com/icat/

The rest of the team was motivated by their previous work exploring the relationship between artificial intelligence and creative processes. For example, Thomas' essay 'Between the Boys and their Toys' is about portrayals of teenage boys and robots in films such as Short Circuit [30]. In Correspondence (1992) [31], she explored artificial intelligence, referencing Minsky's statement [20]:

> When people ask, '*Could a machine ever be conscious*?' I'm often tempted to ask back, Could a person ever be conscious?

More recently she interrogated human-machine interaction via the Internet in Hello World (2004) [32]. As a digital writer, Joseph is interested in answering the question: to what degree is it possible for machines to create believable creative texts? Perril paper on '*Poetry and Artificial Intelligence*' [24] explored the parallel interest in human perception and information processing in contemporary experimental poetry. As a Creative Writing tutor at DMU, his first year undergraduate module 'Writing Identity' has allowed him to return to exploring creative negotiations of otherness.

2.2 Buddy-ing Devices

A number of buddy-ing devices started to emerge[2] in an attempt to capitalise on educational, entertainment and therapeutic applications helped by advances in cognitive robotics research. Recent advances in the field of cognitive robotics ventured into the irrational aspects of human reasoning. This led many to investigate the role of emotions and previous perceptual experiences (i.e. beliefs) in influencing the reaction towards the same stimulus. The aims are to develop systems that can cope with limited knowledge and uncertainties in dynamic environments similar to the way humans do. This is very important for the development of robots that are capable of co-existing and co-working with humans because human decisions and actions are influenced by emotions, perception, beliefs and personality.

Games are often used to realise emotions and personality modelling. In game applications, a mixture of internal feelings and external physical abilities and constraints are modelled part of the perceived environment. They often generate interesting ludic experiences[3] such as panicking crowd running towards danger instead of running away, or users of wii breaking their LCD TV. These experiences lead to interactions within spaces, both virtual and real, where characters engage in the narratives of everyday behaviour. A buddy-ing device needs to be able to engage in these narratives and initiate new interactive narratives. These do not have to be verbal or strongly structured. Finally, a buddy-ing device can easily, or arguably must, become the subject of another interaction and narrative.

2.3 Aesthetics of Interaction

Aesthetics [15, 2] is the science of analysing and evaluating, subjectively or objectively, the creative product of human thoughts, i.e. arts. It has great association with appearances and perception. The shift in the discussion from the aesthetics of design to the aesthetics of interaction perception is important for several reasons. Firstly, the users will not experience interaction unless they perceive that an interaction is taking place. Secondly, the perception of the object being interacted with, including its appearance and function, will greatly influence the decision to initiate an interaction experience with the object. Only then can an evaluation of the object's aesthetic merits can take place. In this paper, we show through experiments, in a later part of this paper, this link between perception, in appearance and function, and the interaction experience.

Many previous studies focused on the aesthetics of design [18, 22] with particular focus on the analytical side of aesthetics. In other words, many of these studies focused on measurements and criteria for evaluating, what seem mainly graphical, designs in systems [9, 19, 7, 8, 10] , rather than the philosophical questions behind their measurement and criteria including user perceptions. Thus any attempt to translate these models to aesthetics of interaction is likely to fail with no guidelines available to support such translation.

The need for aesthetics of interaction is becoming clearer every day with the increasing number of personal devices emerging in the market. These personal devices have the potential of becoming the buddy-ing devices we aim for, however, they often suffer from a short life cycle with speedy detachment from the user; number of people with multiple mobile phones is a good

[2]Another example from MIT http://robotic.media.mit.edu/projects/theHuggable.html in addition to iCat and AIBO

[3]For example, AI. Implant (http://www.ai-implant.com/) was utilized by the first author on another project for developing a realistic crowd simulation

example of this fast shift. Also, advances in domestic robots and intelligent monitoring systems call for such devices [11, 4, 25, 12, 28, 14]. The design of mobile devices and educational toys is shifting, or arguably should be shifting, towards Buddy-Like devices with all-encompassing functionality. One can give examples from devices such as the iPod and wii.

It has been argued that translating existing measurement systems is not a viable option in assessing the aesthetics of interaction, especially where Buddy-Like devices are concerned. The alternative would be to start from a potentially viable object from the perspectives of both aesthetic and interactive functionality. Given such an object, we can then observe the reaction to and the reflection upon interaction experience by a group of non-technologists, i.e. users of technology but not producers. This is exactly the approach this paper pursues.

3. Buddy-ing Experimentations

A number of experiments have been conducted using Sony AIBO as an example of a buddy-ing device to examine the relationship between appearance, user perception, the robot's functional behaviour, and user acceptance of the buddy-ing experience.

3.1 Experimental Setups

We have conducted several experiments over a year and a half. The aim of these experiments is to gather information about the user's perception and interaction with AIBO robots in various settings. We aimed to cover unstructured interaction, individual interaction, and group interaction. We also tried to cover an intersection of these various types. For example, for unstructured interaction, we have setup an AIBO robot in an office, section 3.2, where staff and visitors were free to interact with the robots as they wish. This covered unstructured interaction individually and in a group over long period of time. A similar unstructured environment but within time and space constraints was our AIBO Saloon experiment, section 3.4. It was a group interaction in free space and format but within limited time and within specified space boundaries.

For structured interaction, we introduced the robot in creative writing workshop and in undergraduate creative writing course, section 3.5.

Capturing the feedback and results of these experiments was challenging. We used variety of techniques. For example in AIBO Stories, section 3.3 we used discussion forum to capture feedback through out the workshop.

Another form of capturing feedback was to supply a questionnaire. The questions were trying to capture the participants impression related to aesthetical features, e.g.:

- Your first impression of the dog:
- Your first impressions about the dog was influenced by:
- If the AIBO did not look like a dog, would you:

Please see appendix A for the questionnaire and sections 3.5.3 and 3.6 for summary of the outcome.

These experiments ran over 18 months, which was a long period of time. Each experiment was run by one or more of the authors of this paper. The result was variety of techniques and approaches. In an attempt to formalise these experiments in a standardised format, each experiment is presented here in a separate section with three elements: Participants, Settings and finally Method and Results.

3.2 AIBOs in the office

3.2.1 Participants

The AIBO robot was set up in the office of the Dean of Humanities. The participants included two groups. The first group consisted of the members of staff, two secretaries who looked after the robot and thus formed his buddy-ing group. The second group consisted of visitors; that group in turn consisted of two groups, regular visitors, i.e. members of staff, and irregular or new visitors. All participants interacted with the robot freely.

3.2.2 Settings

The AIBO robot was placed in a free-range environment in the Dean of Humanities. The only constraint put on the robot was the

range within which it could roam freely. It was confined to the office and the corridor front of the office. The robot remained there for a year starting from its birth, i.e. booting the robot to operation. While the other AIBOs in the robots' laboratory and in the IOCT operate together, the Humanities AIBO engaged only with humans and has never seen or interacted with another AIBO.

3.2.3 Method

This was the first experiment to be conducted. The aim was to find out what kinds of stories people may start telling about their new buddy robot. In analysing these narratives, some conclusions on their perception of appearance-function and how theyrelate to the robot can be drawn. Thus the method used here is a free interaction and informal reporting. The following is an example of such reporting:

> To date, the Dean's secretary Kirsty Byrne reports that the AIBO has definitely shown (and is showing) continuing improvements in speech, e.g. it now says *Sayonara* as a farewell, and favours people with more animated speech patterns, ignoring those with more monotone or quiet voices. But, Kirsty continues, the AIBO dog seems to have become lazy in terms of its mobility. Kirsty's given reason for this is the limitations of office space, which does not provide it with a very large roaming environment. Another explanation is that the office environment provided limited opportunities for playful interaction.

It also has been perceived to be the case that:

> In line with this more sedentary life, the AIBO now asks to be picked up from the charging station, rather than making an attempt itself. It is unclear if this is a change in the dog's settings or a question of perceived assumption by the people in the office. Indeed the current perception is that , as it is programmed to do, the Dean's AIBO has become not dissimilar to a family dog in social status and behaviour.

It was clear that the robot started to take a status of a more living object than just a robot especially within the buddy-ing group. Yet although they have not named him, which indicates a degree of refusal in accepting this piece of technology as a buddy, they have started to refer to it as if it learns, lives and socialises. Their association of the dog with a family dog is also an indicator that there is a degree of experience projection influenced by appearance. This projection is re-confirmed in experiment 2 with undergraduate students.

The reports from the second group, i.e. visitors, had less significant value to our study here. The participants had interacted with the dog, found it amusing, but it had a short life span in their daily conversation. This gave us an indication that regardless of the aesthetics of interfacing, unless co-inhabiting happens to enforce familiarity, acceptance of the technology beyond office hours is less likely. In other words, it remains a device of work necessities, but never a buddy.

3.3 Public (Creative Writing) Workshop 1: AIBO Stories

In June 2006, Professor Sue Thomas conducted a public Narrative Lab workshop day for writers interested in new media, funded by HEIF open freely to the public. The intention was to examine the outputs and reports of an AIBO to discover whether they contained elements of what might be called the machine's own story. The intention was to use a phenomenographical approach, collecting and analysing the AIBO's activity logs. Without making any assumption of consciousness, Thomas imagined that the standard textual outputs might express some kind of coherent lifeworld generated from basic programming. Such material is usually only examined by programmers, but a writer might make a different interpretation of the narrative embedded within the logs. As the experiment got underway, the question that emerged was what kinds of stories might people tell about an AIBO?

3.3.1 Participants

Participants were creative writing group. They come from different walks of life but with common characteristics:

- All are writers.
- All are involved in technology or new media.
- All wanted to explore other means of inspiration especially using new technology.

3.3.2 Settings

The AIBO Stories session was described as '*a writing workshop about encounters viewed through the eyes of a robot dog and*

its observers'. The workshop comprised two one-hour long sessions, i.e. the experiment lasted for two hours. The setting involved the use of two rooms (A and B) with wireless connection. The group was split into two groups. One group (G2) accompanied the robot dog in room B whilst the first group (G1) at room A observed the events in room B through projection of the robot vision system on a screen. G1 and G2 then exchanged places.

3.3.3 Method and Results

During the presence of each group in room A, they were given the chance to ask questions that may help them to write a short story about seeing the world through the dog's eyes (i.e. what is happening in room B). Similarly, each group was permitted to interact with the robot physically during their presence in room B to help them with writing their views about the robot from outside. In other words, the experiment was attempting to capture the participants' perception of the dog internally and externally.

In fact, no writing took place because the group was very excited about interacting with the AIBO and was also extremely keen to simply discuss what they were seeing. It appeared to the workshop coordinators that the participants were less interested in creating '*AIBO Stories*', and much more interested in holding a lively discussion about the implications of artificial intelligence. For many, this was the first time they had ever knowingly engaged with AI, although of course all would have previously unknowingly engaged with it in many facets of everyday life, and their narratives were those of deep speculation and enquiry rather than the traditional and deliberate story-making the workshop had been intended to produce.

The first observation made during the free contact session is how many participants made a connection between the look-behaviour of the AIBO robot and their own previous experiences. Many people seemed to project their own feelings and habits onto the dog. The first reaction seemed to be stroking it on the head and back in the same way they would do to a real dog. They were often reluctant at the beginning to accept it as anything other than a novelty item, but when it started to move and produce sounds the level of interactivity increased. The more the dog demonstrated emotional expressions, through sound, light or gesture, the more attached and empathic the users became.

In one demonstration, Dr. Ayesh switched off the dog while carrying it, causing it to collapse. This drew a sigh of sympathy from the audience and provoked questions about the ethics of switching it off. The only explanation can be given is that the audience projected their own sensations and experiences onto the dog triggered by watching its apparent lapse into unconsciousness.

A relationship between interactivity levels and curiosity levels was also observed. The participants often became more inquisitive as they interacted with the robot. Again, the more time spent on knowing the dog the more attached the users grew. The type of attachment and its level differed from user to user and from context to context. In the office, it became part of the office. In the classroom, it was the subject of fascinated study. In the laboratory and IOCT, it is part of a community of other machines.

3.4 PublicWorkshop 2: AIBO Salon

3.4.1 Participants

This was an open workshop as part of on running IOCT activities: the Salon Series. There were about 40 participants from various backgrounds and age groups. They contrasted strongly with the first public workshop in their diversity and reasons for being at the Salon.

3.4.2 Settings

The Salon started with a RoboCup style football game, which everyone watched. The game was followed up be an open session of questions and answers, which was led by Professor Thomas, Dr. Ayesh and Steve Grand. The session was then followed by free style interaction with the robots. While the setting was focused primarily on the AIBO dog robots other robots such as ActivMedia PeopleBot were present.

3.4.3 Method

Because of the style of the Salon, capturing opinions, reactions and position shifts was difficult. The main opportunity was during the questions and answers session. It was clear that there is a divide on technology and how far people may allow it to be elevated from the position of tools to anything near a buddy device. While everyone enjoyed the dance routine at the end of the game, a few were hostile to the idea of robots being intelligent or demonstrating characteristics of living things let alone imitating humans.This finding interestingly contradicts some of the findings from the next experiment in which participants liked

to see the robot taking on more human look. Nonetheless, the look and the behaviour seem to be two different things, as participants perceive them in the majority of the experiments conducted.

The second observation is that experience and personal interest was a big decider in how people reacted to the robots. The psychologist with interest in behaviour and his son, who likes games, were far more interested and positive about the robots than the majority. While artists and designers who do not work with kinematics arts were less interested in the robot behaviour. Similarly, a number of participants were far less sure and demonstrated apathetic reaction to the whole event.

The third observation is that people, regardless of how hostile there may be during the questions and answers, were less had reserved during the free interaction. It seems a close personal interaction has more of a disposition of curiosity and less of a philosophical stand. This is in particular an important derivation for buddy-ing devices; they should be *personal* and far less ideologically *confrontational*. Finally, the participants had a passive attitude, neither hostile nor positive, toward the PeopleBot robot even though it is far more advanced. The only conclusion that can be drawn is the aesthetical appearance that made people not relate to the PeopleBot.

3.5 Undergraduate creative writing workshop

3.5.1 Participants

The participants were first year Humanities undergraduate students. The number of participants was 40 students and the workshop was part of their studies. The workshop was led by Creative Writing and English lecturer Dr Simon Perril and IOCT Digital Writer-in-Residence Chris Joseph and dubbed *Project AIBO Oracle*. The format of the workshop took the following setting:

> The Module consists of two groups of approx 20 in each. In week 1 of this project, the 2 hour workshops were divided into two: 1 hour was spent in a classroom interacting freely with two dogs; the second hour was spent at the IOCT consulting the '*Oracle*'. The Oracle was no other than and IOCT Digital Writer-in-Residence Chris Joseph. In week 2 the students brought in their creative pieces to the workshops to be read and discussed.

3.5.2 Settings

The project AIBO Oracle was presented to the students as a project that focussed around otherness and exploring this concept in creative writing. The students were given the following instructions [23]:

> Dear writers, Last week we were exploring our relations with objects our projection of significance onto inanimate things so they become talismanic; charged with something that potentially reflects our own identity.
>
> This week, I want you to think about relations with animals - and particularly how our fascination with their otherness encourages us to project human qualities onto them. Read the passage from the memoir of Australian writer Robert Adamson [1] in the attached file.
>
> Think of the line '*I wanted to will myself into the bird's head, though not exactly to tame it.*' Whilst pondering these ideas, your task for next week's workshop is simply this: if you had access to the thoughts of your pet dog; what would you want to know?
>
> Come to the workshop with 10 questions each - the more inventive the better.

What the students didn't realize was that the next workshop was to involve an unannounced encounter with a couple of AIBOs, and that in the second half of the session they were going to ask their prepared questions of the AIBO '*Oracle*' housed in the IOCT. Equally unbeknownst to them, the oracle was simulated by Chris Joseph, remotely watching and listening to the students through the AIBO's audiovisual software, and communicating with them through text-to-speech software. A sample of the questions they asked, though admittedly often prompted by Simon Perril, are:

- Do you dream? of what?
- Do you believe in the supernatural? Have you ever seen a ghost?

When were you born? What is your earliest memory?

• What was your first emotion?

• Do you feel sensations? What things give you pleasure? What gives you pain?

• If you were a real dog what would you really like to do?

• If you could get to do anything, what would you want to do?

• Do you have an imagination? What do you use your imagination for?

• Can robots be original?

• Do you have free will? (can you choose what you want to do?)

• Have you ever been in love? What did it feel like?

• When humans are very sad, they cry; what do you do?

At the end of the session students were given a task in preparation for the next workshop: they were asked to write a creative piece exploring the '*consciousness*' of an AIBO, in the form of an interior monologue, a blog or journal entry, a poem, an AIBO fiction or any other form, as long as they were writing from an AIBO's perspective.

At the following week's workshop, the students were given a handout explaining to them the reasons for setting them such an idiosyncratic task. The handout is excerpted below:

Why are we thinking about Robots and AI (Artificial Intelligence) in a '*Writing Identity*' creative writing class?

To explore whether technology can simulate consciousness/intelligence, is to simultaneously explore some of the mysteries of what it means to be human, and have an identity and sense of self. Have a look at the extracts below from Hofstadter [17]:

3.5.2.1 Intelligence and Emotions

Or consider this tiny yet poignant story:

Margie was holding tightly to the string of her beautiful new balloon. Suddenly, a gust of wind caught it. The wind carried it into a tree. The balloon hit a branch and burst. Margie cried and cried.

To understand this story, one needs to read many things between the lines. For instance: Margie is a little girl. This is a toy balloon with a string for a child to hold. It may not be beautiful to an adult, but in a child's eye, it is. She is outside. The "*it*" that the wind caught was the balloon. The wind did not pull Margie along with the balloon; Margie let go. Balloons can break on contact with any sharp point. Once they are broken, they are gone forever. Little children love balloons and can be bitterly disappointed when they break. Margie saw that her balloon was broken. Children cry when they are sad. "*To cry and cry*" is to cry very long and hard. Margie cried and cried because of her sadness at her balloon's breaking.

This is probably only a small fraction of what is lacking at the surface level. A program must have all this knowledge in order to get at what is going on. And you might object that, even if it "*understands*" in some intellectual sense what has been said, it will never really understand, until it, too, has cried and cried. And when will a computer do that? (p. 675).

3.5.3 Method and Results

The outcome was initially analysed through verbal feedback. Responses to the AIBO workshop itself were mixed: in one group, the encounter with the '*Oracle*' took a while to get beyond scatological questions that - at least initially - diffused the explorative nature of the exercise. This was partly because a couple of students at the back of the class had noticed Chris Joseph sat intently at his laptop - and so the '*ruse*' was up. The other group - with Chris now safely invisible - seemed more comfortable, more willing to enter into the spirit of the exercise. In both groups, the response to the written task that the initial '*Oracle*' session was designed to stimulate, varied; some students were patently unsure of what was expected from them, others were clearly stimulated by what they were being asked to think about. The following week's workshop, when students brought with them the writing that the initial session had provoked, proved that the sessions had achieved more than the tutor originally thought. Those who had taken the task seriously produced varied and exciting pieces: an exploration of the death of the Oracle and its consequence for the rest of the '*pack*'; an AIBO Creed written as a Declaration of Independence; a satire upon the Oracle session itself; assorted poems that challenged the perceived artificiality of the AIBO, and disputed a robot's incapacity to feel emotion. of particular interest here are the opposing trends resulting from the task of exploring the consciousness of an artificial

intelligence: students either used the AIBO perspective to articulate a sense of the rise of AI as a potential threat to human individuality, or used it to expose a lack of humanity within supposedly human beings.

The actual writing was not analysed any further in relation to this research since it gives very little feedback on how the participants viewed the robot, the oracle and the experience. Thus, a questionnaire was used to capture their view with some interesting results. Figure 2 shows the distribution of answers to 10 questions, included in Appendix A, related to the students experience. The answers to the questions were distributed over 4 groups ranging from very positive to very negative in response to technology, except for (Q8) which had two choices only and interlinked with (Q9).

There are several conclusions that we can draw from this diagram. Firstly, most participants' first impression was influenced by its look. That perception, however, changes as they interact with it. If we crisscross questions and answers, we find that many of them found it interesting but were not sure how useful it was to their work, i.e. writing. This fact led some of the participants to have negative views on usefulness of the workshop.

The majority did not relate to the robot (Q8), and those who related to it did so because of their previous experiences (Q9), in other words they were influenced by the fact that the robot looks like a dog. However, lack of response to (Q9) on the questionnaire renders the few answers received statistically insignificant.

The questionnaire had also two free-style questions to capture qualitative evaluation of the robot. The first question related to first impressions of how the robot looked. Table 1 shows a summary of the results.

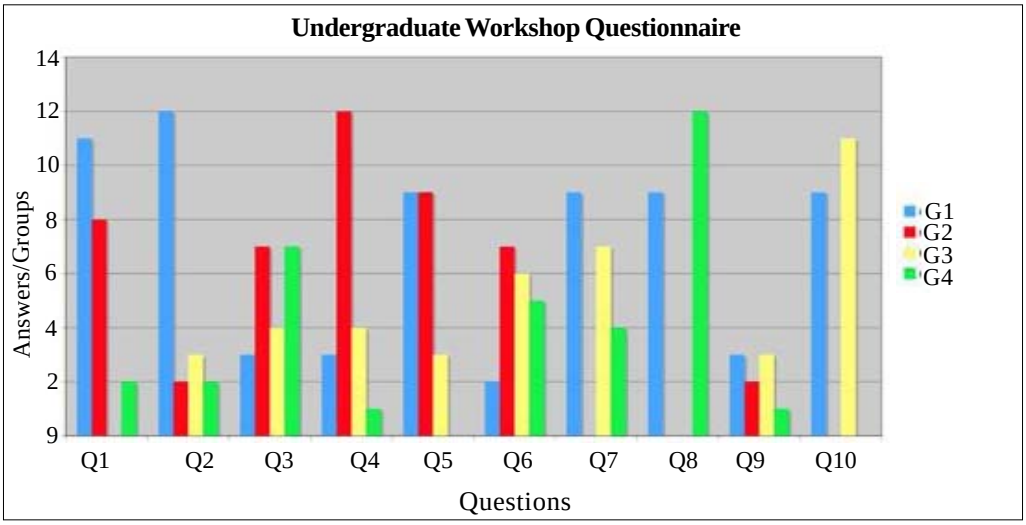

Figure 2. Distribution of Answers

Looks	No.
Other Animals	4
Human-like	1
More realistic (bigger, fur, sensors)	4
Nothing	2
Like-me	1

Table 1. Looks Feedback

It emphasises the results from the multiple-choice questions. Participants relate to the device if it is in animal form, i.e. if they can relate it to previous experiences with pets. A few suggested a human form, which was unexpected, as was the suggestion of making it bigger for better interaction. Table 2 which summarises the results to the second question shows again human form as a suggestion. In addition, it highlights clearly the functionality, e.g. walking, as an important aspect of perceiving the device to be aesthetically convincing in its role.

Others/Functionality	No.
More dog look and functionality	4
Walk better	1
Human-like	1
Not sure/tricked	2
Nothing	0

Table 2. Functionality Feedback

Experiment	No. of Participants	Length	Qualitative Outcome
Free Contact at Office	3+ visitors	1 Year	Shift in Cultural Attitudes
NLab Workshop	20	1Hour	Positive and curious enquiry intellectual enquiry
IOCT Salon Workshop	40	3Hour	Mixed intellectual
Undergraduate creative writing	20	4 Hours	Pieces of Writing Class

Table 3. Summary of Outcome

The results here re-affirm previously drawn results from the less formal experiments.

3.6 Summary

Looking back at the observations made and conclusions drawn, we can summarise our findings in table 3.

In the case of the free contact experiment in the office, there have been changes in the way the robot is treated. Over time, the robot seems to have been accepted as an addition to the office environment. There were changes in the robot behaviour at the same time. This may give us an opportunity to develop cognitive systems that mirror complex social environments (e.g. the workplace) and through the study of such behaviour changes understand the mechanics governing a given environment. This gives us a tool for change management.

In the case of Narrative Lab workshop (AIBO Stories), the questions triggered by the AIBO and what it can or cannot do were overwhelming. The interaction led to dialogue. This has important implications for developing educational games and interactive systems, being for entertainment or therapy, based on narratives [26, 29], especially those created for adults. The participants in this workshop were at graduate level and mature in age, bringing knowledge and life experience to the discussion. Participants in the undergraduate workshop were generally younger and perhaps less sophisticated but the variety of output they produced also supports the view that for an educational game that is based on narrative, we need:

- Objects of familiarity to encourage dialogue and interaction
- Means of dialogue that trigger curiosity and exploration - this means we do not have to have *making-sense* verbal dialogue
- A context that relates user to object and encourages exploration

4. Analysis: Metric Framework for Buddy-ing Devices

At this point the results of the experiments will be analysed to deliver guidelines on developing buddy-ing devices. We will discuss the aesthetics of interaction measurements in such devices. Then, a metric framework is proposed.

4.1 Aesthetics of Interaction in Buddy-ing Devices

Experience influences the perception of a given device greatly. Positive previous experiences make the device more acceptable. In addition, any perceptual projection on the device can help the user to relate to the device. In the case of the AIBO dog, people could not help attributing dog features to it and patting it.

Also experiencing the device itself changes these views, as was the case with AIBO stories in which the group G2 was more pro-active in asking questions and G1 had more questions once they experienced the dog physically. However such experience may

take the *magic* out of the device and the views fall back on technology being purely technology.

In considering the aesthetics of interaction in a buddy-ing device experiential projection seems to be the judge of the device aesthetical value. The interaction that follows is derived by this first impression. However, continued interaction is strongly influenced by purpose. This may explain why undergraduate students were not sure on how useful the experience they had with the robots to their writing even though the majority agreed it was an interesting experience.

The behaviour of the device is also a factor in assessing the aesthetics of interaction. There is a balance needed between realistic behaviour, functional purpose, autonomy, and user control. Above all, a level of gradual personalisation is required. Most people who have the AIBO dog over a weekend reported positive attitude towards the dog. It was theirs and getting used to them. The reporting often treated the AIBO robot as if it was a real dog. This gradual personalisation relates also to experiencing the device. This is another factor which is establishing two ways interaction, user gets used to the device, device gets used to user; all with minimum presence felt of this process.

4.2 Metric Framework for Design and Assessment

From the experiments conducted one can recognise that a buddy-ing device has to encompass certain aesthetical characteristics to be acceptable by users. The seriousness of application, accessibility and personalisation are some of the most important factors that influence the user reactions toward a device; thus influence the interaction. These characteristics are summarised in our framework into two main factors. First factor is Physical existence (Ph) to which users can relate or a physical connector such as the case with wii game console. Second factor is Functionality of the device (F) and how similar that to the intended application or imitated life form, e.g. a dog. These two factors are determined in the presented Ayesh Buddy-ing Device Metric Framework (ABDMF) by number of metrics. These metrics were chosen as a result of the analysis of the experiments conducted and data collected, and could be interpreted qualitatively or quantitatively. These factors are:

• **S:** The size of device or interface need to be adequate for the purpose and interaction expected.

• **Pr:** The physical device need to be less confrontational and has somewhat discreet presence.

• **Pe:** The device need to be personal. This is different from customization, which users often do not use. The user needs to feel that the device or system is learning and adjusting to it through interaction. In other words, it is a smart system but without confrontational intelligence.

• **App:** This factor reflects the application and users' expectations in the context of the given application. Adjustments that take long time and very discreet is suitable for domestic applications but far less so for commercial one where results need to be apparent, timely and accountable. In other words, a buddy-ing device function has great implication on the aesthetics of interaction that concerns its behaviour.

• **HF:** Human factors (HF) variable refers to variety of factors that would impact on the design such as culture, gender, age and so on.

• **N:** The device or system need to be accessible naturally, i.e. voice, touch, etc.

The following equations provide an abstract model in an attempt to provide a quantitative evaluation of aesthetical design for buddy-ing device. In doing so, we define two scales: Abstraction Scale Level (ASL) and Functional Scale Level (FSL)

Equation 1, which calculates the ASL, is to assess the look of the device or interface. It answers the question of how fluffy shall my buddy be?

$$ASL\,(Ph) = [(S \times (Pe + Pr)) \div App] - HF \qquad (1)$$

The physical look of the device is based on the application and human factors, in addition to the above factors mentioned. The Abstraction Scale Level (ASL) works in inverted mood to the physical appearance. In other words, the lower the ASL the more abstract the device or the interface with little aesthetical visual details.

Equation 2, which calculates FSL, assesses the functionality of the device against a scale of critical functions implementation. In deciding the functionality scale level accessibility is an important factor. ASL is also a factor. A device or an interface that is used in critical applications needs to have less visual details to simplify accessibility.

$$FSL\,(F) = [(App + N) \times (Pe + Pr)] \div (ASL \times S) \qquad (2)$$

It is likely that the Ayesh Buddy-ing Device Metrics Framework (ABDMF) has to be applied with less precision and more creative attitude due to the nature of its components, which could be interpreted either qualitatively or quantitatively. As an example, the recently released devices of wii and iPhone have interesting interfaces and provide a good example of aesthetically appealing designs. In wii case the device is very abstract in details but the visual appearance is in the console display. The physical device is just a carrier of motion. In this case we have two ASL values one for the user appearance Ph_U and one for the device appearance Ph_D. These two values have an inverted relationship. In the case of iPhone, the device and its interface are fully integrated. Thus, a critical balance between ASL and FSL is required. In addition to creative use, the design of the various scales used in these calculations, e.g. HF, will have a great impact on the performance of the model. These scales are subject of further research. Whilst current literature emphasizes the impact of cultural differences, personality traits, and individual experiences, there is very little research on how we may capture these differences in a format that is suitable to adjust systems without re-implementation.

5. Case Study: AIBO Dog vs. iCat

iCat robot is Philips creation[4]. iCat platform is a good comparison to the AIBO dogs on many fronts. Both are robots; both were built with social interaction in mind; and both are programmable. However, they contrast in two features: the AIBO dogs are mobile whilst iCat is more emotionally expressive, figure 3. As a result, iCat has been tested in applications related to teaching children or in game interaction [16, 27, 33] as means of interface rather than as a physical existence such the case with AIBO dogs applications [3, 21, 13, 6], which also include assisting children in learning or assisting the creative process through physical space interaction such the case in our experiments.

Table 4 summarises the common features of both AIBO robot and iCat platform. Due to the qualitative nature of interaction, the table does not provide numerical testing of these features. It is rather an indication of the presence or the absence of the feature. For example, emotional indicators in AIBO are lights where red indicates anger or annoyance, green happiness. However, there are other subtle gesture indicators such as tail and ear movements. However, these movements are so subtle that may be missed by some users or contributed to other qualities. Contrastingly, iCat adopts more human facial expressions in cartoon style that makes it ideal educational toy than entertainment interactive artificial being. This feature of iCat is emphasized by the absence of mobility.

Let us adopt a scale of 1-10 in translating these features into the variables required by AMF. Table 5 presents an estimate of the metrics based on the features presented in table 4 and the discussion earlier in this section. Please note we have chosen to neutralise the human factors (HF) for the purpose of this study. The reason is that HF is based on number of variables that are outside the scope of this work and requires a dedicated study in the relationship between human cognition, personality and the device aesthetics.

Figure 3. iCat robot - courtesy of Philips Research
http://www.research.philips.com/technologies/projects/robotics/images/icat-1.jpg

[4] For more information on iCat please see: http://www.research.philips.com/technologies/projects/robotics/

Robot/Features	AIBO	iCat
Mobility	Yes	No
Interactive Sensors	Yes	Yes
Emotional indicators	Lights	Facial expressions
Functionality	Dog behaviour	Interactive game like behaviour

Table 4. AIBO vs. iCat Summary of Comparative Features

Robot/Metric	AIBO	iCat
Pr	8	7
S	8	8
Pe	9	6
N	8	8
App	7	6
HF	1	1
ASL	18.43	16.33
FSL	1.73	1.39

Table 5. AIBO vs. iCat Estimated Metrics

The AIBO robot scores high ASL level, which means it has lower abstraction. This is understandable in relation to its mobility and imitation of real dogs, which makes it a good companion and buddying device. It also scores highly on FSL, which means it has the functionality required for the wide range of applications expected from a buddying device in the form of a dog. Contrastingly, iCat scores lower on both, which indicates more abstraction and limited functionality as a buddying device. This reflects the fact that iCat is a physical platform for representing facial emotional expressions, which would enable us to study interfacing, but makes relatively a poor buddying device.

It is clear from the numbers that we have to apply qualitative interpretation to the numerical results given. There is also the question of what is the threshold, if any, which indicates a good aesthetical design.

6. Conclusion and Future Work

Several experiments concerned with the aesthetical perception of interacting with an AIBO dog has been presented. The results of these experiments have been analysed. In conclusion, a metric framework for the design of buddy-ing devices has been proposed.

A future work of this research is to allow the users to interact with the AIBO robots using handheld devices such as tablets and smartphones. Preliminary experiments with mobile phone based robot control and robot control through Access Grid have been already conducted.

Another future work is to repeat some of the experiments with devices designed based on the Metric Framework and apply the equations to validate the mathematical model. To do so, some collaboration with product design researchers will be required. Initial testing may be conducted through simulators and software based interfaces within the context of entertainment computing before venturing into physical devices.

7. Acknowledgements

The authors would like to acknowledge the support and funding they received from HEIF and IOCT, and to thank all the participants and helpers in the workshops who are too many to name.

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