Designing smart toys for the cognitive enrichment of elephants

Conference or Workshop Item

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Abstract. This project investigates the potential for designing playful cognitive enrichment activities for captive elephants. We explore the usefulness of applying conceptual frameworks from HCI and game design to the problem of developing species-specific smart toys that promote natural behaviour and provide stimulation.

Figure 1. Tanya, matriarch at Colchester Zoo

1 INTRODUCTION

Wild elephants spend most of their time foraging, often covering daily distances of 20-30 km with their herds. Their social interactions are complex and wide-ranging and their awareness of their environment – space, proximity, locations of resources and conspecifics - is well-documented by Poole and Granli [1]. By comparison, captive elephants in wildlife parks and zoos have less opportunity and less need to exercise their natural intelligence, as they are usually maintained in herds and spaces that are much smaller and their basic physiological needs, such as food and water, are provided without threats from predators.

One implication for elephants in captivity is that in their current situations, diverse recreational experiences might be desirable. Elephants are the focus of this project because we believe that their social nature and cognitive abilities indicate that while in captivity, they might show interest in a smart toy or game.

According to Goodenough [2], young mammals play for many reasons, including: [i] practising skills they will use as they grow, such as hunting and fighting behaviours, [ii] reinforcing social bonds, [iii] establishing hierarchies by understanding their own physical limits and those of others, [iv] exercising. Bekoff and Byers [3] describe how playing is an important part of normal development.

Adult animals, on the other hand, rarely exhibit playful behaviour, probably because in the wild they have to spend their time foraging or hunting to survive (consistent with Maslow's Hierarchy of Needs [4]). Recent research has shown that they play more when their dietary requirements have been met – typically in captivity [2]. According to Young [5], the introduction of toys to captive animals can provide useful environmental and cognitive enrichment, promoting the expression of natural behaviour patterns which might otherwise not be expressed.

Recent research and development investigating technology-enhanced toys and games for animals includes "Playing with Pigs"[3], a game developed for livestock in Utrecht, TOUCH[4], a project using touch-screen technology to enable humans to play games with orang-utans and "RoboBonobo"[5], which gives bonobos control over a robot. In each case, the main objective was to enhance the animals' well-being, which involved investigating how best to mediate their interactions with the system.

Play may be encouraged through simple physical interaction or using technology for more sophisticated interaction. One of the advantages of using technology to facilitate a playing experience is that it can enable the collection of a rich set of data from the participants, which can then be used as metrics for further analysis of behaviours. The Internet of Things (name attributed to Ashton [6]) technology, which is beginning to enable a vast range of smart wearable and ambient applications to enhance human well-being and life experience in a variety of contexts (Aarts & Encarnação [7]), can potentially be used to develop different kinds of non-invasive and non-obtrusive interfaces, such as motion sensors, GPS tracking devices, touch screens and physical objects, in order to improve and measure the well-being of captive animals.

The emerging area of Animal-Computer Interaction (Mancini [8]) aims to broaden the scope of established Interaction Design (Rogers et al. [9]) frameworks to include animals and develop technology that can support them in different ways. Directly contributing to this wider endeavour, this project is the first to focus on the development of user-centred technology and design frameworks to support elephants by fostering their well-being.

In this paper, we discuss the rationale for offering game experiences to captive animals and consider possible aims for elephant enrichment, derived from studies of their lifestyle in the wild and behavioural observations collected during fieldwork in

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[3] http://www.playingwithpigs.nl/
[4] http://ludusanimalis.blogspot.co.uk/p/touch-project.html
[5] http://spectrum.ieee.org/automaton/robotics/robotics-software/robobonobo-giving-apes-control-of-their-own-robot

a variety of captive situations. Based on our initial observations and specific interaction and game design principles, we propose early design guidelines for developing species-specific games and we describe the future direction of our work.

2 TOYS AND GAMES

Toys and games have been part of human culture for millennia[6], providing focus and structure for our playful instincts.

The National Institute of Play[7] identifies the following "patterns of play": attunement (between infants and parents - important for emotional development), body play (the somatosensory system and exploring one's physical boundaries), object play (toys and "making" activities), social play (with others, often structured), pretend play (using imagination), narrative play (story-telling to make sense of the world) and creative play (for inventions and new ideas).

Human children show a natural facility for freeform play, but as they become more mature and analytical, unstructured play is replaced by activities that have explicit sets of rules for players. These kinds of games generally include a competitive (and sometimes a cooperative) element within a rule-based system. They explore core dynamics, such as racing, chasing and evading, prediction, collecting, spatial reasoning etc. These are all skills that humans must develop in order to survive in the real world. Games take a serious subject and give it a light touch, enabling players to engage with abstract (and therefore safe) versions of reality through metaphors and symbols.

Games as diverse as football and chess cross linguistic and cultural boundaries, providing a framework for non-verbal communication between people who might otherwise not interact. Sometimes, playing can even forge friendly relationships between individuals of different species, such as humans and dogs, dolphins and humpback whales[8] or polar bears and huskies[9]. The rules of engagement in these scenarios are implicit – bluffing is permitted, but not real aggression; the game continues for as long as both parties agree. Pierce and Bekoff[10] explain that play between animals is constantly negotiated, noting: "Four basic aspects of fair play in animals are: Ask first, be honest, follow the rules, and admit you're wrong." Elephants have also been observed playing[11] freely like this, but we do not know if they are interested in or capable of playing more structured games.

According to Schell [10], there are four mental abilities that enable us to play structured games – (i) modelling (because reality is incredibly complex), (ii) focus (selective attention leading to a state of flow), (iii) imagination (putting the game into the player's head) and (iv) empathy (so that the player cares about different characters).

Do elephants possess similar mental abilities?

McFarland [11] comments: "Different species in different environments exhibit a wide variety of types of intelligence." He points out that such intelligence is difficult to define and that we should strive to study it from a design point of view (meaning how a particular aspect of intelligence, such as the ability to communicate using ultrasound, has evolved) as well as looking at the mechanisms involved.

This means that it is necessary to consider how the species achieves autonomy, meets goals, exhibits behavioural flexibility and communicates its intentions, all of which are topics dealt with in the following section on elephant lifestyle.

3 ELEPHANT LIFESTYLE

Elephant society is naturally hierarchical, complex and consists of multi-levels of units (Langbauer [12]). Asian and African elephants all live in societies that are matriarchal, matrilineal and matrilocal. The oldest female leads the herd, comprising her closest kin (sisters and calves) and their offspring. Daughters spend their whole lives with their mothers, forming family bond groups. Sons stay with the family until they mature at around fifteen years, at which point they disperse and often form associations with other young bulls.

Certain aspects of elephant behaviour raise the possibility that they are capable of creating mental models – the first of Schell's prerequisites for being able to play games [10]. Wild elephants have home ranges that cover hundreds of kilometres (Leggett [13]), which raises the possibility that they are capable of creating models of the landscape. They spend around eighteen hours of each day foraging, and are well-known for covering vast distances in order to find food, water and partners for mating.

Poole and Granli [1] state that: "Elephants need to walk to stay well." They argue that elephants have evolved physically and behaviourally to meet their "long-distance" lifestyle. Adaptations include a water storage pouch inside their mouths, specially cushioned footpads, good geographical memory and the ability to maintain group cohesion, which requires communication between members of the herd and associated elephants.

Communication between animals occurs when they are able to give, receive and interpret signals (Pearce [15]). Research on elephant communication has shown that they use multiple modalities in order to send signals to each other[12] [13]. Acoustic communication can occur over both long and short distances, using a range of frequencies including infrasound (McComb et al. [16]). Chemical signals are regarded as more "honest" because they are associated with the physiological condition of the elephant and are therefore difficult to "fake" (Schulte et al. [17]). These also persist in time, whereas tactile and visual signals are usually intentional and momentary.

Langbauer [12] identifies a number of reasons for elephants to communicate, including the advertisement of emotional and physiological states and the mediation of daily interactions within their group.

Poole and Granli [1] believe that two to three family groups (about 25 individuals) is an appropriate amount of associated elephants in order to allow the development of a complex "fission-fusion" society, where individuals can make choices about social relationships and learn how to cooperate and communicate using a wide repertoire of vocalisations. Their

[6] http://en.wikipedia.org/wiki/Toy
[7] http://nifplay.org/states_play.html
[8] http://www.amnh.org/explore/science-bulletins/(watch)/bio/news/whales-give-dolphins-a-lift
[9] http://www.youtube.com/watch?v=WCJ5_Oc2T3g
[10] http://chronicle.com/article/Moral-in-ToothClaw/48800/
[11] http://www.youtube.com/watch?v=icWOPQTkVh0 (Cambodia); http://www.youtube.com/watch?v=KuXAlVLB_9M (ZSL)
[12] http://www.elephantvoices.org/
[13] http://www.birds.cornell.edu/brp/elephant/index.html

remarkable ability to distinguish between the vocalisations of all their close family members as well as associated bond groups suggests that they maintain a mental model of their extended family.

The second ability that Schell claims is necessary for enjoyment of games was described by Csikszentmihalyi [14] as "flow", which results from an uninterrupted focus on an activity. Do we know whether elephants can also experience this state of mind? We know that elephants will focus on food, since they normally spend the majority of their time foraging, but it is not clear whether the act of eating truly occupies their concentration in the same way that certain activities can engage human brains.

Being capable of imagining a game scenario is the third mental ability that Schell identified [10]. The topic of imagination in animals is controversial. However, Mitchell [21] has examined pretence in primates and concludes that they can and do pretend, as this ability is necessary in order to make future plans. While elephants have large brains, they have not performed well on some of the cognitive tests at which primates excel, such as tool use and "insight behaviour" (Hart et al. [22]). Nevertheless, their memories (of geographical space and being able to discriminate between conspecifics using vocal cues) and their aptitude for numerical cognition appears to demonstrate a higher intelligence (Irie & Hasegawa [23]).

There is evidence that elephants feel empathy (Schell's fourth mental ability), as they have been observed protecting weaker members of the herd from predation and appearing to grieve for dead conspecifics (Douglas-Hamilton et al. [18], Bates et al. [19]). Recent work on elephant cognition has demonstrated that they are capable of mirror self-recognition (Plotnik et al. [20]), which is considered to be an indicator of empathetic and cooperative behaviour.

Thus it may be that elephants meet many of the requirements for being able to take part in a structured game. The next section considers some of the reasons why this might be desirable for captive animals.

4 ELEPHANT ENRICHMENT

Records from the Absolute Elephant Encyclopedia[14] show that there are currently 15 male and 50 female elephants held in captivity in the UK, distributed among 16 institutions. Only Howletts, Chester, Whipsnade and Knowsley keep herds with more than 4 animals. Many of these groups consist of unrelated elephants. If elephants in the UK were encouraged to breed naturally and form herds with their kin, the rising populations would require more land. Space in zoos and wildlife parks is restricted, and therefore so are the opportunities for elephants to live in a natural society, map their environment and communicate over long distances.

Poole and Granli [1] comment: "A [wild] elephant's daily life is distinguished by need, purpose, challenge, choice, will, autonomy and camaraderie." They point out that their captive counterparts do they have as much purpose or challenge in their lives, as they are not motivated by the need to find sufficient nourishment. Their choices are restricted; autonomy and free will are subjugated to the rules of living in a managed enclosure, which may also have effects on camaraderie.

Poole and Granli [1] identify other problems associated with a captive existence, including obesity and arthritis, exacerbated by remaining stationary for long periods.

As a result of these health problems, enrichment for captive elephants often aims to encourage exercise and foraging behaviour within the confines of the enclosure, by distributing food widely and using puzzle feeders to restrict access, requiring the animals to search, stretch and use their trunks. For example, at Colchester Zoo, treats are concealed around the elephants' outdoor paddocks, while the indoor housing area has hay nets suspended from the rafters. Colchester also implements a regular "feed the elephants" experience for visitors. This is offered to all the visitors, but to only two of the elephants, who are habituated to human contact and known to behave predictably.

Figure 2. Foraging at Colchester Zoo

A major challenge of this work is to comprehend something of the quality of life experienced by an elephant, in order to create playful scenarios that elephants might find interesting and engaging. To paraphrase Mulholland and Collins' definition of a story [24], we are aiming with a game design to create a conceptual space representing elephants, objects and events. Interacting with this space may evoke for elephants some of the qualities of Huizinga's magic circle [25] - the abstract, imaginary, highly-structured world that humans willingly enter when they agree to join in a game.

The following section offers some criteria for game design, based on fieldwork and research.

5 GAME DESIGN BRIEF

How might an activity that it is a valid form of enrichment and attractive to a captive elephant be designed? Schell [10] emphasises "game experience" as a core motivation for human players, offering feelings such as control, freedom, responsibility, accomplishment, friendship and trepidation. Taking part in a game experience therefore involves learning about the system and possible interactions, understanding how to achieve goals, developing useful strategies and probably practising particular physical actions.

As Wirman comments in Ludus Animalis[15], with reference to designing games for animals, "If game design is about designing experiences, it is crucial [for a game designer] to be able to imagine that experience." In Matt Allmer's[16] 13 principles of game design, he stresses the importance of the designer being able to understand the players and to lead and

[14] http://www.elephant.se/

[15] http://ludusanimalis.blogspot.co.uk/

[16] http://www.gamasutra.com/view/feature/3949/the_13_basic_principles_of_.php

direct their experience. Schell [10] states: "The most important skill for a game designer is listening."

We propose that there is a need to broaden the scope of Schell's claim to include the use of other senses that might help us to make sense of another species' forms of communication and interaction. Initial fieldwork is being carried out systematically with simple equipment – pen, paper and hand-held video camera. It is anticipated that more sophisticated data gathering equipment will help at a later stage, by capturing data that humans cannot perceive, such as infrasonic sound waves.

By Interaction Design standards, technology should be easy to use in order to support users in the accomplishment of given tasks, but it should also offer the user a stimulating and enjoyable experience [9]. Games in particular are designed to tease – to be sufficiently challenging without being too tough, to progress the player through a pre-authored narrative, to drip-feed rewards and to excite the senses.

The well-established heuristics for interaction design developed by Neilsen and Molich [26] emphasise ease of use and transparency of system status in order to reduce cognitive load. Recent work defining heuristics for game designers adds more elements to this toolkit. Desurvire and Wiberg [27] point out: "Some types of difficulty are desirable." Their work on PLAY heuristics includes aspects such as challenge, strategy, pace, coolness, entertainment, humour and emotional immersion, as well as covering familiar techniques for evaluating design, such as consistency, clarity and control.

Based on preliminary data and the review of literature pertaining to elephants outlined above, we propose the following design criteria for a game aimed at addressing some of the issues faced by captive elephants:

- Exercise: The problem of lack of motivation to move extensively suggests a playful enrichment device should include the requirements to promote physical activity and exercise different muscle groups.
- Motivation: Any game or toy must be able to engage elephants' curiosity and have some intrinsic reward system.
- Reward system: Because elephants spend so much time searching for food, it might seem obvious to use nutrition as a pay-off, but this raises questions that can undermine the game design process – how can we tell if the elephant is enjoying the experience? For an animal that has evolved to forage, food is the ultimate distractor/motivator. We will investigate whether an elephant would choose to play if the rewards were associated with alternative stimulation, such as an auditory or chemical feedback.
- Cognitive stimulation: The game should be sufficiently challenging, requiring the application of cognitive abilities, possibly including pattern learning. Ideally, it should have replay value.
- Cooperation: The requirement for elephants to cooperate could be built into a game design, but we do not know whether this would be beneficial, because zoo animals have different backgrounds and personalities. Social contexts for captive elephants rarely replicate wild conditions.
- Modality: An important consideration is the choice of modality used to enable interactions with the enrichment system, given that elephants communicate using auditory, chemical, visual and tactile signals.
- Choice: The game should be a voluntary activity, rather than part of a training regime.
- Control and feedback: The controlling mechanisms should have clear affordances for the elephants, such that the behaviour required to operate the controls should mimic behaviour they would use naturally in the wild.
- Catharsis: Games for humans provide fulfilment as well as excitement and challenge. There is often a narrative and always an end-point to reach. Much of their appeal derives from this encapsulation of life into a discrete experience.
- Competition: It is at present unclear whether games should have a competitive element, because we do not know how the captive elephants will play together. Hierarchies have already been established and we do not want to introduce unnecessary stress.
- Scaffolding: Any complex activity should be scaffolded in terms of difficulty and progression, so that the early stages are easy to accomplish, but that the activity gradually becomes more challenging.
- Alternative versions: We would like to develop an alternative human interface in order to make comparative studies on play behaviour.
- Data capture: In order to analyse the play experience, the system should include data capture (of all players).

6 CONCLUSIONS AND FUTURE WORK

This research aims to show how smart games and toys have the potential to engage species and stimulate natural and intrinsically beneficial behaviour patterns. The symposium presentation will showcase the fieldwork undertaken as part of an ethnographic study of captive elephants in a UK facility. It will highlight some of the best practices currently in place in zoos and wildlife parks and suggest potential directions for the development of playful cognitive enrichment devices.

We will also present some concepts for species-specific games/toys and a description of progress to date. Investigating the usability of a range of such toys or games will be part of subsequent research into elephant ergonomics.

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