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More than Human Aesthetics: Interactive Enrichment for Elephants

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ABSTRACT

Species-specific aesthetics is an important consideration for interaction designers working with animals. The paper explores the concept of species-specific aesthetics with particular reference to elephants. Applying existing aesthetic dimensions and design principles to the challenge of designing interactive enrichment for them, we show how the insights gained can inform more than human centered design in different settings. We offer a multi-faceted, multi-sensory lens for examining an animal-centred aesthetic experience of technology.

Author Keywords

Aesthetics, Animal-Computer interaction, elephant, haptics, acoustics, Research through Design, UX design, environmental enrichment.

ACM Classification Keywords

Do Not Use the Old Classification System

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• Human-centered computing~Interaction design

The New ACM 2012 Classifiers must be used:

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INTRODUCTION

Consumer-driven design for humans places great emphasis on *aesthetics*, which in popular parlance has come to mean the sensory qualities of an object or image that give it broad appeal. We argue that interaction designers focusing on animals might design intrinsically better systems by considering the aesthetic dimensions of their products. For example, von Gall and Gjerris suggest that there are welfare implications relating to aesthetics, in that they may increase an animal's pleasure [34]. Because humans make the decisions about purchasing animal-related equipment,

designers may be tempted to appeal to the human's sense of aesthetic rather than to that of the non-human user. However, this could impair the user experience and therefore the very functionality of the product. For example, an animal user might choose not to play with a game that did not satisfy its sensory experience, which would defeat its original purpose.

The aesthetic principles that Western humans have traditionally valued tend to be strongly associated with our visual perception, exemplified by modern dictionary definitions – (i) M-W define the adjective "aesthetic" to be "relating to beautiful, artistic, attractive (*pleasing in appearance*)"; (ii) Cambridge English state: "relating to enjoyment or study of beauty, showing beauty" [20] [5]. Yet the aesthetic qualities of an experience vary considerably from species to species, depending on which sensory, cognitive and physical characteristics mediate the animal's perception and interaction with its environment [10]. In consequence, an exploration of alternative sensory and related emotional values is required in order to understand which qualities have a range of appeal for non-human animals.

While there has been significant research in Animal-Computer Interaction into interfaces for animals that are practical and usable, enabling interactions with computer-based systems, there has been less emphasis on the potential *pleasure* associated with the encounter [11]. This is especially important for interactions whose purpose is to positively enrich the life of prospective animal users. In particular, our work has focused on the development of interactive enrichment for elephants and, in the course of working with these animals, we have found that the mindful consideration of aesthetics has given us insights leading to novel design decisions.

Environmental enrichment aims to enhance the psychological and physiological welfare of captive animals by promoting species-specific behaviours. Differences between species are expressed in their normal behaviour, such as how they interact with the world and with their conspecifics, their daily activities and how they perform their usual routines. It is evident that aesthetic sensibilities vary when we compare the activities of different animals. For example, Plotnik [23] reports that, as a part of their self-maintenance and social bonding routines, chimps spend time grooming each other while elephants have mud-baths and

spray dust on their bodies (Figure 1). In both cases, these activities enhance the health of the animals' skins while also providing significant tactile stimulation, except that the chimps are removing dirt while the elephants are applying it. These differences in daily practices and aesthetic experiences influence the way in which different species respond to external stimuli, sometimes leading us to misinterpret their capabilities. For instance, the mirror recognition test, typically used to verify whether an animal is capable of self-awareness, involves painting a mark on an animal's face and checking to see if the animal touches the mark when they look at themselves in the mirror, implying that they recognize their own reflection. Plotnik's theory is that, given their grooming habits, chimps might be expected to notice a strange mark on their bodies; on the other hand, given their bathing habits, it is hardly surprising if elephants pay little attention to such a mark and does not necessarily mean that elephants are any less self-aware than chimps.

Figure 1. Elephant mud bath, Colchester Zoo 2014.

Furthermore, research has shown that elephants' sight is relatively poor, and that they have dichromatic vision and can see clearly only as far as the end of their noses [35] [30]. Elephants' olfactory and auditory senses, on the other hand, are superb [24] 26]. Thus, arguably the design of experiments that aim to understand animals' capabilities should be informed by their species-specific sensory characteristics. By the same token, when conceiving enrichment ideas, it is arguably essential for designers to focus on aesthetic aspects that are consistent with and relevant for the species' sensory characteristics – in the case of elephants, tactile, olfactory and auditory senses – rather than focusing on aspects that are typically of human concern such as the visual appearance of a system.

In this paper, we explore some ideas about aesthetics in general and contemplate how these might apply to the development of interactive systems for animals. In particular, we describe our work on aesthetics for elephants, showing what materials were used to craft enrichment devices; we explain the design choices we made in relation to aesthetic dimensions of the physical interfaces and show how an aesthetic framework can be useful for analyzing and developing interactive systems for animals.

BACKGROUND

Aesthetics as a cultural experience

Aesthetics as a philosophy deals with what is pleasing to the senses and emotions and intellect. It is not simply about what we perceive but more importantly about how that perception affects us at a visceral and a cognitive level. Even within humans, let alone between humans and other species, there is debate as to whether it is possible to talk about "universal aesthetics" (which would be shared by everyone) because many modern philosophers believe it is inevitable that judgements about aesthetic quality are embedded in cultural contexts and prior experience [4].

For example, in Western culture, aesthetics has been strongly influenced by the work of Greek and then Medieval scholars [REF Roger Scruton] who emphasized ideals and perfection in design. These ideas tended to be abstract, leading to a regimented approach to artistic representation that focused on things like proportion of form (Greek sculpture) while often ignoring self-expression. In the 19th century, Hegel broke away from this tradition, claiming that beauty is a manifestation of freedom, impossible to present in a regular symmetrical form, but owing its nature not only to harmonious relationships between components and but also to its inherent "spirit" [33]. But Hegel's insights did not have much influence during this period of his life. Paradoxically, this was also the era when aesthetics gained most traction as a philosophical theory associated with fine art – in other words, as a visual phenomenon with strict rules of presentation.

By contrast, the Japanese approach to aesthetics encompasses a more holistic appreciation of the designed object. In a philosophical sense, the object represents its place in society, always embodied in context. A well-known example of this design aesthetic is the concept of *Wabi-sabi*, denoting artefacts organic in form, inspired by or derived from nature, unique (one of a kind), personal, crude or rough and encouraging the expansion of sensory information. According to Koren [16], Wabi-sabi "exemplifies many of Zen's core spiritual-philosophical tenets." He elaborates by citing intuition and unconventional ways of thinking. Koren states that Wabi (roughly translated as "subdued, living in nature") references a way of life, a subjective perspective, a philosophical construct and the spatial arrangement of objects, while Sabi (historically meaning "rust or impermanence") references aesthetic ideals, materiality, an objective perspective and, crucially, the passage of time. This is why weathered or disintegrating objects may poignantly express Wabi-sabi, reminding us that all things pass. This sense of mortality and melancholy is also illustrated in the term "*mono-no-aware*" which emphasises and celebrates the transience of things: hence the annual cherry blossom *Hanami* festival.

Similarly, for centuries in the West, a connection with nature was deemed essential for artistic expression, but in the form of *mimesis* – whereby a designed artifact was expected to

imitate a natural form in a formal and figurative manner – very unlike the Wabi-Sabi aesthetic.

Thus, we can see how two human cultures have developed distinct aesthetic sensibilities, which strengthens the argument that a "universal aesthetics" may not exist. It may equally be true that there exists no "one-size-fits-all" approach when designing artefacts for more than humans, yet there is surely enrichment to be found in variety. Although the philosophical features of Wabi-sabi (such as celebrating impermanence) would probably be irrelevant for an animal, the emphasis on natural forms and evidence of history might hold some interest for a species that disregards perfection of shape but appreciates chemical signals.

Aesthetics as a multidimensional experience

The word *aesthetic* derives from Greek, meaning "sensitive … pertaining to sense perception or sensation" [8], which suggests a wider experience of pleasure than conveyed only through a vision. In Ancient Greece, aesthetic values were applied to all the arts, including music, poetry, architecture and drama. These were important media that served to both entertain and educate, whereby an aesthetic experience became the vehicle for intellectual growth and moral development [28].

Clearly, in contemporary design, a range of physiological principles come into play, reflected in the great variety of shapes, textures, sounds and smells featured in many everyday objects. For example, the smooth surfaces and rounded edges of mobile phones are designed for enjoyable hand-feel as much as visual appreciation. However, until the 20th Century, the discourse on aesthetics in design was mostly limited to visual aspects, possibly because vision is such a prominent sense for humans. Indeed, Diaconu suggests that olfactory aesthetics has been neglected [6] because of its ephemeral nature and our lack of sensitivity to smells, and the resulting poverty of linguistic expression with regards to olfaction. Nonetheless, recently Huss et al [15] have explored olfactory aesthetics with regards to humans' relationship with flowers, describing this as an embodied aesthetics whereby we experience pleasure through interactive stimulation.

A parallel perspective is found in the recent conceptual framework of Somaesthetics, developed by Richard Shusterman [29]. This emphasises that beauty is not only related to the visual experience, but also to the appreciation of other embodied sensory experiences, including feelings derived from physical actions. Others have built on this, suggesting variations that focus on human experiences of sound, touch and the resulting perception of design itself [18] [27] [14]].

Rooted in Dewey's exploration of aesthetics as an emergent phenomenon [19], Flanagan proposes an aesthetics involving the temporal interplay of dimensions of experience other than the usual five senses [9]. She attempts to define a "ludic language" emerging from gameplay and game design, arguing that the prevalence of play culture has permeated other media to the extent that it has created new linguistic frames of reference. A game designer's craft is to sculpt player experience – itself a multisensory and intellectually engaging activity – so that it is as pleasurable as possible. Flanagan shows that it is possible to make judgements about the intrinsic values of particular game design components, based on how they affect human emotions and intellect, just as it has been possible to apply a value system to visual aesthetics. Flanagan describes well-known game elements such as control systems, inventories and HUDs (Heads-Up-Displays) as memes, entering the language as experiential components. These elements are not directly related to individual senses, but encompass the overall *performative* experience of play, which involves both subjective duration and enactment of gameplay sequences. The temporal aspects of gameplay and the performance itself are therefore identified as having their own distinct aesthetic values. [9]

Arguably, this widening of perspective on what constitutes aesthetics can help inform design work for non-human animals, for whom "doing" is an essential part of their aesthetic experience. This is one of the reasons why our work has focused on designing interactive devices that offer their users some control over their experience. This has clear parallels with both gameplay and tool use, in that animals are enabled to engage directly with an artefact and make decisions about what to do in order to achieve different outcomes, through a performative experience. Moreover, our evaluation of systems for animals tends to focus on their actions, which we can attempt to interpret through methodical observation; actions are easier to measure than emotional responses when we lack a shared interspecies language with which to explain nuance.

INTERACTIVE ENRICHMENT

In our project with elephants, the overarching aim was to explore the use of technology to enhance environmental enrichment experiences for these animals. In order to understand the difference between the aesthetic experiences of elephants living in different conditions, we initially investigated and compared the behaviours of wild and captive elephants. We then worked with keepers and animal experts to identify potential enrichment goals, which had to be appropriate for the elephants, but also feasible within the means and scope of the project.

Within elephant herds, there is a strong hierarchy and a lot of communication between family members, which implies that acoustic discernment and response is part of their natural behaviour in the wild. Our main objective therefore became to provide acoustic and cognitive stimulation in order to offer the captive elephants a facet of the wild herd experience which they might lack in their daily life. Beyond this we were committed to offering choice and control to our users, because the experience of performative aesthetics requires the animal to be able to interact with their environment, rather than be a passive recipient of stimuli.

On this basis, we proceeded to brainstorm concepts and craft prototypes to test in the field. Our main tester was an Asian female elephant living in a countryside sanctuary in Wales. We installed various prototypes inside her elephant shed over a period of several years. Other testers were African males, housed in a zoo in southern England.

Our key commitment was not only to produce systems that were functional, but also to try and enhance the quality of the interactions from an elephant's perspective. This involved experimenting with different input and output methods and devices, and assessing them both in usability terms and according to their potential for being pleasurable or intrinsically appealing for the elephants. In doing this, we took a Research through Design approach because it offered a reflective, iterative design practice, ideal for exploring a previously unknown area, particularly the subtleties involved in designing for aesthetic experience [11].

Throughout the research, we produced a range of prototypes at varying levels of fidelity, which aimed to provide a variety of enriching experiences from controlling water jets to playing natural and musical sounds. The following sections explain our thinking around prototype designs and exemplify our research in relation to the aesthetic dimensions of interactive enrichment devices for elephants.

AESTHETICS FOR ELEPHANTS
Interacting with a computer system is a form of conversation, with the user providing input and the system outputting a response. Our research addressed the question of what design qualities an interactive system would need to have when designing interfaces and experiences for elephants, in order to best support such a conversation.

Design ethics
To contextualize our work in the contemporary environmental and cultural climate, we have ascribed to design values that we feel are supportive of both sustainable development and environmental ethics. This was consistent with the aim of designing technology for animals who are often kept in captivity for conservation purposes due to the environmental degradation and habitat loss that is now threatening many species' survival. We established some key principles at the start that have underpinned all our subsequent development work. In particular, we wanted our designs to be:

- Eco-friendly – we always attempted to *recycle* found objects, such as drainpipes, ropes and plastic buckets; we used off-cuts of wood to *reduce* waste; we repurposed existing mechanisms in order to *reuse* objects.

- Natural – most of the prototypes were crafted from materials that would be encountered naturally by a wild elephant, such as wood and plant-based textiles.

- Simple – the principle of KISS (keep it simple, stupid) was applied to our work, both to aid technical development and

construction, and to facilitate the inclusion of non-experts in the team.

- Open-source – we wanted to share projects with the wider community, enabling greater collaboration, so we used free software and development environments such as Arduino, Audacity, MicroPython [1] [2] [21].

Five senses +
Every device we created had visual, olfactory, aural and tactile properties – each physical object within reach could be seen, smelled and touched, and in each case the feedback or output from the device had an audible aspect. Some of these features were specifically designed to be part of the system (for example, knitted textile interfaces); others were inevitable (for example, the scents added by humans manually crafting objects). We were careful to avoid using food as part of or as a reward for engaging with our systems, as we were keen that the devices should have intrinsic appeal and not be related to foraging behaviour or fitness. However, the sense of taste is closely related to the sense of smell and we were not able to judge whether chemical properties of the devices would also have gustatory appeal.

We do not know whether the ability to analyse one's perception and to distinguish between different sensory modes is part of an elephant's cognitive abilities, since it implies an awareness of each sense as a distinct element. Our experience of life tends to integrate all our senses simultaneously, so it seems likely that an elephant would gain information and understanding in a synaesthetic and holistic way. This is not to say that changing a small part of one aspect of an interface element could not have a significant effect on the overall experience, by targeting a particular sense.

The following sections discuss elephants' different senses and describe how our designs related to these.

Smell: Olfactory aesthetics
Elephants initially use their trunks to smell the world around them. They have a large vomeronasal organ situated in the roof of their mouth. In order to perceive a scent in more detail, they may flehmen, which involves sniffing the scent sample with their trunk (akin to the nose in humans) then placing the trunk tip into the mouth to access this special organ. They can also detect chemical signals using taste [17] [31].

Although chemical signals are synchronous, they may persist for hours or days or months once the object or event they signify is no longer present. Their range is both near and far, depending on the senses of the perceiver and external factors such as humidity and wind. They are therefore a 'material' that is hard to control. Furthermore, as we have indicated earlier, humans currently have a poor understanding of olfaction, epitomized by a lack of vocabulary to describe different aromas. This made it very challenging to use smell in our designs.
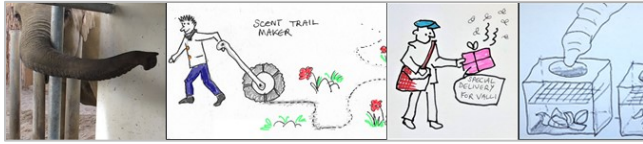
Figure 2: Concepts for olfactory enrichment

We did consider some early enrichment concepts that used olfaction. These would have included scent trails in the environment, stool samples from hitherto unknown conspecifics, and pungent boxes to explore (Figure 2). However, none of these concepts gave the recipient much control over their experience because smells are pervasive (like sound), yet have no "volume control". Only the pungent boxes afforded a measure of choice if the olfactory stimulus was weak. Although every crafted object that we subsequently developed was permeated with scents that an elephant could discern, and which therefore contributed to the overall aesthetic experience of the device, we were not in a position to appreciate the effect of and make decisions about this property of our designs. We therefore directed our attention to alternative sensory stimulation.

Taste: Gustatory aesthetics

One of the things that engages all our senses simultaneously is food – unsurprisingly since it is vital for survival. In human food technology, quality criteria include mouth-feel, smell, taste, acoustics (e.g. crunch), colour and presentation.

It might be assumed that most non-human animals eat to live, with foragers spending such large portions of their time searching for and consuming food, and hunting occupying a significant part of predator time. However, non-human animals can also be selective and may make choices related to aesthetics as well as self-preservation [32]. Our experience with our Asian elephant tester offers anecdotal evidence of food appreciation. One time, she was given a tiny piece of chocolate by her care-giver as a treat; instead of chewing and swallowing it as she might have done with a cabbage leaf, she kept it in her mouth, swirling it around until it melted. One might suppose she was savouring the smell, the sweetness, the taste and the mouth-feel, much as a chocolate-loving human would do.

For the reasons discussed earlier, it was important that during our research we tried to avoid food associations,. However, we do recognise that gustatory aesthetics would be an interesting topic for future exploration and likely very popular with any non-human client.

Sight: Visual aesthetics

Elephants have limited visual acuity. African elephants can discriminate a gap of 2.75cm about 2m from their eye – in other words, at the end of their trunk – while Asian elephants can discriminate at a much smaller distance (0.5cm) [30]. However, anecdotal evidence from the Elephant Voices site [7] points to the idea that elephants can recognise shapes very well, and that they can determine small changes in another elephant's demeanour from a significant distance – when a human might require binoculars.

When testing with elephants, we noted that if our devices were not visible to them they were less willing to interact than if when they were visible.. Early prototypes were placed in areas of the elephant's environment that were trunk-accessible but hidden from view; our Asian female elephant needed to be shown that a new device existed, which turned out to be a problem because one of her care-givers used fruit as an olfactory lure. Having established that bananas might be a feature of the new experience, other pleasures became insignificant for our tester, so we were unable to gauge her interest in alternative sensorial aspects of the design. In the zoo environment, we installed a prototype that would allow the elephants to touch buttons in order to trigger different sounds. Our system was placed above eye-level, and initially ignored by the two African elephants. Only when they were far enough away to spot a new object mounted on the fence did they spontaneously return to engage with it. We hypothesise that unless a system produces a continuous noise associated with it or emanates a pervasive and interesting smell, it needs to be clearly visible.

As mentioned previously, elephants have dichromatic vision (they see yellow, blue, black, white). One of our prototype controls was a panel of touch-sensitive buttons, which were differentiated using a range of materials that offered contrasting colours, textures, positions on the controller and scents. This was the only device that used colour (yellow and blue) as well as visual contrast design features. Video footage analysis of the Asian female investigating the control (Figure 3) shows that she was interested in exploring the surface with her trunk. Although we do not know whether vision played a role in her tactile exploration of the object, it is plausible that its striking visual appearance would have attracted her attention and enticed her to interact with it.

Figure 3. Control panel using blue, yellow and strong contrast to differentiate zones.

When it comes to humans, past experience (memory and cognition) is what enables them to tell, for example, if the embers are hot when we look at a fire. Therefore, human awareness of colour has an obvious fitness benefit, although at close range temperature sensation would render vision redundant. It is plausible that colour perception could be similarly grounded in elephants' biology and that colour might have a useful place in the elephant-interaction-design palette.

Other visible features (size, shape, pattern, location) are discussed in subsequent sections.

Hearing: Auditory aesthetics

Auditory signals are synchronous, and then they dissipate. The distance that an acoustic signal carries depends on how quickly the waveform attenuates, which in turn may depend on environmental conditions such as weather and landscape. Low frequency infrasound (10-20 Hz) is outside normal human hearing range but it persists over much longer distances than higher frequency sounds and is known to be used by whales and elephants to communicate with conspecifics. As well as seismic vocalisations, elephants can generate infrasound using their feet. An elephant stomp can travel up to 32km, depending on soil type for attenuation. [22].

Elephants can detect infrasound through both bone conduction and via somato-sensory perception. Their inner ear has an enlarged malleus, which provides a bone-conducted pathway for seismic signal detection. Elephants can occlude the opening of their ear canal, potentially building pressure in the air canal to enhance bone conduction. In addition, they possess an aerated skull and sinuses, and fatty deposits which may act in a similar way to acoustic fat in dolphins and manatee – facilitating low frequency detection. [22]

We spent a significant amount of time investigating how we might create acoustic experiences that would be interesting for an elephant. Moreover, our intention was to develop digital instruments that could be operated by an elephant, permitting them to control the quality of the sounds being produced.

We identified the didgeridoo as being an instrument capable of generating a potentially interesting acoustic waveform. This was because of the inherent similarity between the shape of the instrument and the shape of an elephant trunk; indeed the kinds of sounds produced when air vibrates inside a didgeridoo have characteristics in common with some elephant calls. On analyzing African elephant calls we downloaded from the open-source repository at ElephantVoices.org [7], we were able to see typical wave shapes and peaks. However, there was less data available on Asian elephant vocalisations.
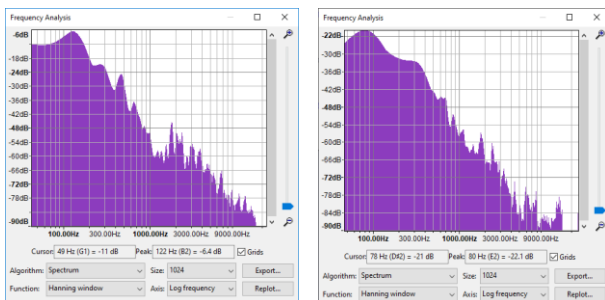

Figure 4. FFT for African female rumble-roar (left) and didgeridoo sample (right).

We investigated this further by running an FFT (Fast Fourier Transform) analysis of (i) an African female elephant rumble and (ii) a didgeridoo sample, showing a strong similarity in shape (Figure 4).

We played short low frequency audio samples (sine waves) to our Asian female participant, to determine whether she might have interest in low frequency audio. Keepers interpreted her posture and reaction, concluding that she appeared to show most interest in samples in the 60-70Hz range. Interestingly, Ayers and Horner [3], identified the fundamental frequency of a didgeridoo as 62.5 Hz with small peaks at 174.5 Hz and 187 Hz.

Recording sound, which is essentially an ephemeral phenomenon, involves capturing and recreating sound waves. Analog recording can be achieved by using a microphone to sense changes in sound waves then transcribing these mechanically onto a (vinyl) record or magnetic tape. Sound reproduction reverses this process. Digital recording uses a sampling technique to capture audio data picked up by a microphone, storing the sound as series of binary numbers. The different file formats used to store audio data vary in the quality of sound they can reproduce. In order to reduce the file size, algorithms (codecs) have been developed that remove audio data that is outside normal human perception, but probably not outside normal elephant perception.

This may reduce the quality of acoustic experience for elephants being played pre-recorded music and other sound effects. The sound quality is reduced at different stages – not only by compressing the digital file but also at the point of playback, when speaker size has an impact on the range of frequencies that can be recreated.

We hypothesise that using a physical resonator (which creates an uncompressed sound) might hold more promise for generating interesting acoustics than a digital file with amplifier and speakers, unless the quality of recordings and playback were exceptionally high.

While the quality of sound is an important aspect of auditory enrichment, the choice of audio in the first place is also critical. For the elephant radio system we installed at the zoo, we were working with colleagues who were animal behaviour experts and who chose to test these options: (i) humpback whalesong; (ii) elephant "rumble-coo" made by mother to pacify calf; (iii) short clip from Bach D Minor for Two Violins. Clearly there is a lot of scope for future research into elephant preferences.

Touch: Tactile aesthetics

Rasmussen and Munger [36] analysed the sensorimotor specialisations in the trunk tip of the Asian elephant and concluded that it was a very sensitive apparatus. They compared the sensory capacity of the trunk tip to the lip tissue of monkeys or to the mystacial skin surrounding a rat's whiskers, stating that this finding correlated with the tactile ability of the trunk, which can grasp small objects and place them into the vomeronasal organ for chemosensory processing.

While elephants' trunks do not possess mechanisms that respond to dynamic changes and control motion and grip, they do possess mechanisms that respond over a larger area to vibrations and changes in pressure, hair-cells for the perception of form and texture, free nerve endings and other receptors [37].

During our investigations, we became increasingly aware of our Asian female's interest in the tactile qualities of our devices. For example, when we presented a large push button made from an old sewing machine pedal, she never voluntarily pushed it, but she did spend several minutes exploring the ridged surface and running her trunk tip around the wooden frame. It was not clear if she was feeling or smelling the interface, or indeed perceiving it with both senses simultaneously. As a consequence, during our system's interface design process, we made many aesthetic design decisions in an attempt to enhance the tangible experience of the interaction.

Figure 5. Some different shapes used for elephant device

As a case in point, initially we offered rounded shapes, taking care to cut out circles instead of squares in an attempt to be less formal and more "natural" (Figure 5). However, corners and edges seemed to generate as much interest from the elephant as curves and moreover, they were simpler to manufacture. We also observed that perfect circles are geometric, rather than organic, and therefore equally out of place in a natural environment.

Other aspects of form, such as size, were more critical.

In fact, scale became a major design challenge due to the geographical distance between the designer and the potential user. Although we understood that the controls had to be an appropriate size for an elephant trunk tip to activate, it was difficult to fully appreciate the scale and strength of an elephant without being in close proximity. Our solution was firstly to use a template – a paper trunk tip to-scale – and then to craft a physical "trunk-glove" that a human could wear in order to test the usability of the interface (Figure 6).
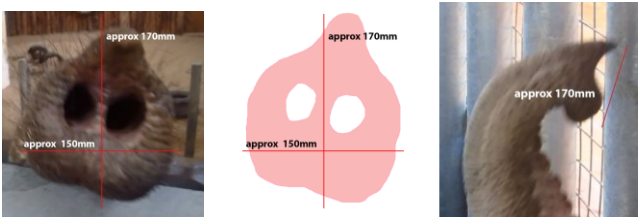

Figure 6. Paper template to-scale

We paid particular attention to certain qualities (temperature, weight, plasticity) that can only be perceived through touch. Variable temperature (for example, of a water supply) was outside our scope due to cost implications. The weight of

our installations was a compromise between making them sufficiently robust and making them portable and easy to mount and dismount. Objects with embedded technology were securely fastened with bolts and the base structures were constructed from 20mm sustainable wooden ply. This meant that the elephant would not gain any kinaesthetic feedback from weight.

Regarding plasticity, we found this to be awkward because we were unable to produce an electronic device that was both safe and flexible. Hanging ropes offered movement, but this was difficult to capture accurately as a digital signal in order to map to an output. For this reason, controls were mostly rigid. On the other hand, we were able to embed tactile haptic feedback into devices in the form of tiny vibrating motors, which we believe would also provide low frequency audio that an elephant could perceive.

Figure 7. Showing range of materials and textures used for elephant devices.

Over time, we experimented with a variety of surface details (Figure 7), repurposing existing items and crafting new textures from natural materials.

Interaction: Performance aesthetics

All the devices installed in the elephant enclosures required interaction on the part of an elephant, and so far we have considered some pertinent sensory aesthetics, such as whether an object is interesting to touch, whether it smells or is clearly visible. These features are designed to attract the user to the device in the first place, while acoustic elements are part of a system design that aims to offer interesting feedback and make the device "sticky". The choice of interaction modes is also important for making the experience pleasurable and we are currently exploring the design of analogue systems that allow greater control and discrimination regarding the nature of the output from the system.

Our early designs focused on functionality with regard to mechanism of activation, and we found that tactile interfaces with hidden sensors worked better than switches that required active pressure [12]. It is likely that an elephant would quickly learn to touch or not touch in order to trigger a reaction and thereby have a choice, but initially at least, these designs force researchers to take a "clandestine" approach because the elephant's actions are being picked up by the sensors whether she intends it or not, which subverts the aim of providing control.

One early prototype aimed to afford our female elephant control over her water supply, by offering a choice of two buttons – one that triggered a jet of water, the other a fine

spray. When these shower fittings were left in place overnight, according to her keepers, the elephant took great pleasure in destroying the control system by grasping wires attached to a microcontroller mounted *on the other side of the balcony fence*. She subsequently ripped the cables into bits, then managed to reach the water pipes providing the shower and apparently "*had a lot of fun with it!!*" (quote from care-giver).

From the keepers' point of view, this activity had been enriching for the elephant, exciting her curiosity, allowing her to express herself physically while engaging with a novel object in her enclosure, and testing both her dexterity and her strength. They believed that the experience would have given her cognitive, sensory and physical stimulation (although clearly not in a way we planned or foresaw).

It might be that we need to rethink the kinds of systems we offer an animal as large and strong as an elephant, if we want them to engage enthusiastically, using their full physical capacity without destroying the source of the entertainment.

We observed an example of a more substantial source of entertainment when watching night footage of the Asian female elephant. We noticed that she spent a large portion of her waking time interacting with a tyre – a large, robust physical object, too heavy to throw but light enough to be manouevred. Firstly, she selected one tyre from a pile on the sandy substrate; then she rolled it onto the rubber floor area under the balcony and close to where her care-takers enter and leave the building. She kept the tyre balanced under her body for over an hour, walking around while maintaining it in this position between her legs.

When we subsequently discussed this behaviour with a keeper, he explained that this particular tyre had a long history. When the elephant arrived as a calf, over 30 years ago, that tyre was her first toy and accompanied her at night when she slept. Around 2010, a new elephant shed was built for her. In order to facilitate the transition from old draughty-but-familiar shed to new heated accommodation with pool, her keeper asked her to pick up the tyre and carry it into the new building. Thus her willing relocation of the tyre, which represented home and security, was the embodiment of her autonomous choice to move; the act of physically bringing it into a new environment gave the elephant control over what was happening.

DISCUSSION

Understanding the other

As well as experiencing the world at a different scale, non-human animals often rely heavily on different senses and certainly have a different set of common sense principles. Other animals lack the exposure humans have had to computer systems and interactions with technology, even if the animals' abilities transcend our own in areas such as pheromone identification or balance. Moreover, physical capabilities such as strength and speed, and psychological motivations such as hunting and foraging may make a significant difference to how an animal perceives and interacts with the world. How can human designers compensate for our limitations?

PERCEPTION	SMELL			TASTE			SIGHT			HEARING			TOUCH			KEY
	fragrant, fruity, woody, minty, decayed															HOW TO DESIGN FOR THESE PERCEPTIONS?
				salty, bitter, umami												choice of material or substance / treatment - design and craft / technological innovation or support
							colour									
										noise, pitch, volume, timbre						
													weight, temperature, plasticity			
	citrus			sour												
	sweet			sweet												
	pungent			pungent												
							texture						texture			
							shape						shape			
							sharpness						sharpness			
							movement						movement - kinaesthetic			
													movement - tactile			
							position						position			
							size						size			
							harmony			melody			harmony			
										repetition / rhythm			pattern			
							pattern									
							edge						edge			

Table 1: How perceptions overlap

For a UX designer working remotely, not in close daily contact with the user, it can be difficult to fully appreciate the qualities of the "other" (more than user) that will help define the most appropriate way of designing an interface or system or experience. [13] While this is true even of humans, who have variable characteristics and requirements within the same species, the dilemma becomes more critical when the user is a different species – in other words, when we are designing for an animal.

Our Research through Design approach has enabled us to engage with this problem in a creative, systematic manner, by crafting multiple versions of elephant enrichment objects and gaining a multi-sensory perspective on aspects of the design

To help analyse sensory parameters, we developed a simplified matrix showing distinct perceptible characteristics of each of the five senses we believe we share with an elephant (Table 1). This table also shows that there are clear overlaps whereby sensory features (e.g. size, sweetness) can be perceived by more than one sense.

It seems that the only feature unique to the sense of sight (at least in close proximity) is *colour*. Many other visual features, such as texture, size and movement, can be perceived without the user being able to see, if such features are sufficiently close and presented in a suitable format.

Pitch, volume and timbre are strongly associated with the sense of hearing. Yet, even this is not clear-cut – noises are created and perceived via vibrations that set up sound waves, and which can also be sensed through touch.

Within each feature, there are many variations in degree and endless possible permutations. The myriad possible solutions for creating interfaces means that designers can begin to experiment with the aesthetics of the object, and in doing so, gain a more subtle appreciation of their user. For example, if contrasting switches are required for different outputs; depending on the sensorial preferences of the user, the switches can be designed so that the user can discriminate between them using smell, or touch, or vision, or sound, or taste, or indeed any combination of perceptions.

For our elephant radio installation, we developed two sets of identical three-button systems. The buttons could be distinguished from each other by position on the wall – they were arranged horizontally not vertically, as we did not want to imply a hierarchy. The two radios needed to be the same so as to avoid competition between the two male elephants in the enclosure – everyone had something to play with.

CONCLUSIONS

The critical features that a system interface needs to be able communicate to its users are differentiation, consistency and graduation. We have been testing prototypes that exemplify the first two features and we are planning future work that explores analogue controls that offer graduated input mechanisms.

Using aesthetics to support the design of systems for non-human animals offers us a chance to explore their preferences and hopefully offer them a more pleasurable experience. As Plotnik reminds us: "The more we understand about how elephants navigate their physical and social worlds using non-visual sensory modalities such as sound and smell, and how their behaviour continues to adapt to ever-changing threats, the better able we will be to effectively work to protect them in the wild." [23] Although we have been focusing on elephants in this project, these comments have broader relevance in the context of our uncertain world.

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