Sound to your Objects: A Novel Design Approach to Evaluate Orangutans' Interest in Sound-based Stimuli

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ABSTRACT

Orangutans show interest in sound-based stimuli, but the auditory enrichment they are usually provided with is either based on human-music, or does not allow for control and choice. In this work-in-progress paper, we describe the design of sound-based enrichment by means of the manipulation of tangible non-technological elements. In doing so, we demonstrate how Animal Computer Interaction research can help in providing animals with more control over auditory stimuli, as well as demonstrating and justifying a novel modality for interaction based on orangutan behavior within our ongoing study. We overview our proposed evaluation, identifying how – through embodying notions of control and choice in design - our proposed system allows for orangutan use to inform ongoing development and design of auditory enrichment.

Author Keywords

Animal Computer Interaction; interaction design; user-centered design; tangible; sound; enrichment; orangutans

ACM CLASSIFICATION KEYWORDS

H.5.m. Information interfaces: Miscellaneous.

INTRODUCTION

Animal enrichment is essential for providing captive animals with engaging and adequate stimuli to "*draw out their species-appropriate behaviors, thus enhancing animal welfare*" [24]. Zoos, in their role as conservational organizations, make huge efforts towards providing captive animals with naturalistic as well as stimulating environments [2]. Recently, the field of Animal Computer Interaction (ACI) [7,8] and zoo practices for animal enrichment have joined efforts towards the design and development of technologically mediated enrichment activities [21]. Technology can offer a whole new range of opportunities for animal enrichment, allowing for more rapid adaptation to new circumstances, specific individuals, and easily introducing new activities within already tested systems, e.g. new tablet-based applications for primates [25]. This rapid incorporation of new activities offers the animals more opportunities for exploration and could help to maintain their engagement and interest.

Auditory stimuli are a widespread form of environmental enrichment, particularly for primates. However due to safety or environmental restrictions, primates have little control over the provided stimuli and interaction has been restricted or non-existent. As a result, enrichment is unable to account for species or individual preferences. Several studies have tried to determine the best music stimuli for different primate species, re-appropriating *human*-music for the purpose. These studies either imposed an unsuitable physical set-up [9], did not allow for choice or creation, or were focused just on musical pieces [16] and not sound stimuli over which the animal has more control and choice.

ACI research can help overcome these limitations and provide primates with more control, intuitive interactions and adaptations of these auditory stimuli. In this work-in-progress paper we present the design of a digital sound-based auditory enrichment, based on a novel interface which interprets the movement of non-technological objects as digital input, overcoming safety and technology access concerns. Instead of providing primates with what we believe it is *music to their ears*, our novel interactive approach gives *sound to their objects*. In this approach, orangutans can explore producing different types and variations of sound-based stimuli by manipulating tangible non-technological objects [12]. By providing control and choice over sound generation, the individual preferences of the animals towards the sound-based stimuli can be studied.

This paper consequently contributes; (1) an account of our animal-centered design process for developing novel digital enrichment for orangutans in a zoo-context, (2) a novel and promising approach for mediating animals' interactions with technology, and (3) a sound-based interactive system designed for orangutans which embodies notions of control and choice in its design as a resource for co-creation. We conclude by overviewing our proposed evaluation.

RELATED WORKS

There have been many studies analyzing the behavioral and physiological effects of auditory-stimuli for primates in captive facilities, which provided contradictory or non-

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conclusive results. Some studies reported decreased stereotypical behaviors when primates were listening to music [4,20], others found no difference in behaviors but instead on physiological measures [1], and some works found differences in both [6]. Several studies have also tried to analyze primates' preferences towards different genres of music, also without yielding consonant results. McDermott et. al. [9] defined a physical set-up which conducted to a least-aversive selection [17]. On the contrary, the work by Ritvo [16] provided orangutans the opportunity to conduct a most-desired choice over different genres of music.

However, none of these works allowed the animals to control which kind of music they were listening to. Moreover, the considered auditory stimuli were human-based musical pieces, reflecting the imposition of human-centered enrichment. Instead of *music*, *sound*-based stimuli could be more appropriate when the appropriate levels of control and choice are afforded to the animal user. In an ACI user-centered perspective, orangutans as target users should be the ones dictating what *music* is for them. In fact, a recent attempt to create species-appropriate music for cats using non-human centric sounds has shown promising results in terms of cats' interest in the auditory stimuli [19].

Within ACI, the use of sound-based stimuli with orangutans has been observed to foster interaction and exploratory behaviors. Hermans and Eggen have developed a cylinder which produces automatically generated instrumental sounds when rotated [3]. Although orangutans showed interest, they had no control over the generated sounds. One step further, Wirman has proposed the development of a game prototype for orangutans in which various poking sticks are used to explore sounds [22]. In this promising work, the interaction has been designed based on the observed preferences and interactions of the orangutans. This approach would account for a more intuitive interaction, allowing the orangutan to focus more on playful interactions and explorations of the system. The work presented in this paper is aligned with this latter idea of exploration and describes the design of a system that would allow to study how orangutans want to interact with auditory stimuli of different kinds, and which type of sounds they would prefer to interact with.

DESIGN PROCESS

Here, we present the design process for the development of a sound-based interactive system for orangutans, following an animal-centered approach [7]. The reactions and demonstrated preferences of the orangutans when using the system will inform the design [5]. Zoo keepers also participate in the process with their expertise and knowledge of the orangutan users. We divide the decision making of our design process into three main areas: (1) the selection of tangible elements as mediators of the interaction, (2) the technical challenges to support this kind of interaction, and (3) the selection of suitable and potentially appealing sound-based stimuli.

Tangible Interactions

Environmental enrichment devices (EEDs) are used across zoos as one of the main forms of enrichment for animals. The use of tools and objects for enrichment purposes is usually meant to simulate the animals´ eating and foraging habits in the wild. Toys and everyday objects of different shapes and materials are also used for providing amusement activities for the animals as well as mental stimulation. Physical activity as well as social relationships are also fostered through the use of objects in their environment. Moreover, there are several animal species, including orangutans, with innate abilities and preferences towards the use and even creation of their own tools [18].

Technology is extremely limited in supporting this mode of enrichment, particularly with primates who are extremely strong, potentially harming themselves on deconstructed technology. Hence, orangutans do not usually have free access to any technology inside their enclosure, instead being handled by a zoo keeper or professional staff. This limits the time in which the animals have access to the technology and impedes their control and choice over when to access the enrichment, and how to interact with it.

The *Kinecting with Orangutans* project [26] provided digital enrichment to the orangutans at Melbourne Zoo by utilizing a Microsoft Kinect device to create touch-aware projections. In doing so, this project allowed the orangutans to interact with the digital projections how they wanted to, and they were given regular free access to the technology over the course of a month. This saw the orangutans interact with the technology in numerous unexpected ways, such as with their body, and also with objects (see Figure 1). This included: spreading wood-wool (nesting material) over the projection, interacting with the projection with toys (plastic balls), which also afforded other means to interact (such as hanging from the ceiling and 'whipping' the screen with a blanket to interact, or attaching a tarpaulin from which the orangutan could hang to interact). These interactions were unanticipated, but afforded by the touch-detection software.

Figure 1. Orangutan using objects to interact with projection.

Based on this predisposition and intrinsic ability of orangutans towards the use of objects, we concluded that a promising and novel approach for interacting with technology would be the design of a system in which these

non-technological objects could afford digital interaction remotely, thus overcoming the safety and physical constraints of technology with primates [12]. Such a system should allow animals to manipulate and interact with everyday non-technological objects inside their enclosure and obtain adequate digital reactions from the system based on these interactions. These responses should be triggered by the system when the manipulations happen from any location and posture within the interaction area. The orangutans' spontaneous manipulations of the object will not be limited or restricted by specific interaction constraints. Moreover, the interaction should not be limited to a specific object. Our proposed approach thus allows orangutans to interact with the system using different elements they have around without requiring to put any special artefact on the object. This novel approach for interacting with digital systems would provide the animals with more control over their environmental enrichment. Eventually they will be able to choose whether and when they want to interact and in which ways by simply manipulating (or not) the objects mediating the interaction.

Technical Development

In order to augment the interactions with non-technological tangible objects, the main challenge comprised how to remotely detect the movements of these objects. An approach such as [14], using depth based information to detect postures was not considered to be as effective with orangutans. A top-down approach from a tracking sensor will not allow for the detection of the hands movements. Moreover, orangutans are likely to manipulate objects from many different postures and not always standing or sitting but also hanging or lying on the ground. Therefore, it was decided that an approach in which the system tracks the objects would be more effective and flexible.

After observing and discussing with Zoo Keepers which kind of everyday objects could be used to mediate the interaction, a wide range of colors, shapes and textures were identified. We considered several approaches for object recognition [23], such as pattern matching. However, this approach would not account for objects made of a non-rigid material. It would also make more complex the recognition of the same object in different positions and rotation angles without previous analysis of the object. The two main challenges to overcome were defined as: allowing for flexibility in the range of objects to be used as mediators, and allowing for easy and rapid incorporation of new objects into the system. We concluded that performing object tracking based on color would be most suitable as objects of different shapes and textures could be used. This technique also allows tracking the object even when it is being partially occluded or handled by the orangutan. Moreover, adding new objects to the system just requires to define the main distinctive color of the object. The only restriction would be that this color is different enough from the surroundings.

The developed system consists of a Microsoft Kinect® v2. This sensor captures both color and depth information of the recorded area at a rate of 30 frames per second, with pixel resolutions of 1920x1080 and 512x424 respectively. The software has been developed using C#, Kinect for Windows SDK 2.0[1] and EmguCV[2] (a .NET wrapper for OpenCV). The Kinect sensor acquires both color and depth streams of information. For each pair of color and depth frames, the system converts the color stream to the Hue-Saturation-Value (HSV) color space. Then it filters the HSV image using the HSV values of the object being tracked. Over this image, which only contains the blobs of the object/s being tracked, it applies a blob extraction algorithm to obtain the blobs representing the objects. With this information, the Kinect SDK is used to determine the position and depth of the tracked object within the image. At this stage, different modalities for producing sounds can be triggered attending to the position and movements performed with the object/s.

Sound-based Enrichment

Auditory stimuli are frequently used with Melbourne Zoo's orangutans. This includes using electronic keyboards, harmonicas, iPad music applications, playing sound from CDs or radio, and when accompanying projected movies. Keepers and researchers widely report on primates' curiosity towards sound-based stimuli [3,22]. In consideration of our interest in providing *control* and *choice* to the orangutans, we concluded that the auditory stimuli should be open to exploration, surprise, and engagement, based on how Zoo Keepers identified the opportunity for such technology and prior work [5,12,22]. We considered stimuli from simple notes or sounds to more complex compositions, without the condition that it needs to sound "nicely" or be "harmonious". Nature sounds were discussed, but have been observed to increase vigilance behaviors in captive gorillas [11] due to the fact that they could not locate the origin of the sound, and therefore were not considered. Instead, the fact that the sound was familiar or recognizable to the orangutans (all raised in captivity) was more important.

Several basic modes of producing sounds based on the manipulations or movements of an object were initially implemented. These basic modalities were shown to the Zoo Keepers to provide them with an idea of the capabilities the proposed system could have, prompting discussion and brainstorming ideas of potentially appealing auditory stimuli The Zoo Keepers' knowledge about the individual personalities of orangutans and the way they interact or produce auditory stimuli during everyday enrichment activities were an extremely valuable source of information to inform the decisions of the sound modalities to be implemented and the kind of sounds and mappings these modalities should offer. After discussion, the following three different modalities for generating sound have been developed for the evaluation of a proof of concept system:

[1] https://msdn.microsoft.com/en-us/library/dn799271.aspx

[2] http://www.emgu.com/

- Noise: Noisy and clanking sounds are generated each time the object is moved. Design decision: Orangutans have been observed producing noise with objects around them.
- Progression: A melody is played while the object keeps moving. If the object is not being moved, the melody is stopped. When the object is moved again, the melody restarts playing from the last point it was stopped. Although this would be closer to music than to sounds, in this case the melody does not need to sound good (it could be stopped and replayed at the orangutans' will). Volume variations of the sounds are also produced based on the speed of the movements performed, i.e., if the object is moved fast the volume would be increased, and if the movements of the object decrease in intensity then the volume would be decreased as well. Design decision: Playing music from CDs, radio or while projecting movies is a frequent form of auditory enrichment at the Zoo and orangutans could recognize the melodies in this modality.
- Continuous: Different notes are generated continuously when the object is within the tracked area. The notes change depending on the position of the object and distance to the sensor. When the object is placed far away from the sensor the notes produced are low-pitched, and vice versa. Volume variations are also produced based on the speed of the movements performed. Design decision: Orangutans are curious about new things happening in their environment. Sound variations within this modality would foster exploration and sustain the novelty factor.

Several sounds have been incorporated into each modality. It should be noted that even though terms such as pitch and note are used here, and this might be terms used by human beings to describe auditory stimuli, it is just a representation for us to understand which changes in the sound stimuli are presented. We ground on the knowledge that orangutans can distinguish between different sources and variations of sounds [9,10], hence notes with different pitch or melodies with different rhythm should be perceived as different stimuli. These variations in the source of the stimuli aim to provide variety in order to foster curiosity, engagement and exploratory behaviors. As the movements of the tracked objects will trigger different sounds, this would allow to study how orangutans prefer to interact and manipulate the objects to, for example, replay a specific sound or keep moving the object to discover new ones. Hence, we could also study which auditory stimuli are more engaging based on the performed movements and analysis of their behavior.

CONCLUSION AND FUTURE WORK

This work has presented a novel interactive approach for mediating interactions within ACI. This approach is based on the use of non-technological tangible objects as proxies to interact with the system. It could be broadly applied within ACI to provide not only enrichment but also control over the environment for different animal species. The developed solution is capable of tracking objects of different shapes, colors and textures. This tangible approach has been applied to the context of designing a sound-based interactive system for orangutans with the aim of providing a more intuitive form of interaction for animals as well as more control over their environmental auditory enrichment. An evaluation of the sound-based interactive system will be conducted in order to study: (1) the application and suitability of the proposed tangible interactive approach, (2) orangutans' interest in sound-based stimuli in terms of their interactions and explorations with the system. The results of this study would help to discover similarities and differences between individuals when interacting with the sound-based stimuli in terms of behavior, movement patterns and activity levels. The proposed interactive approach based on tangible elements would offer the orangutans more control and choice over the provided enrichment, hence these results would inform the design of similar and more permanent installations for animal enrichment based on their preferences on auditory stimuli. It will also help to envision how intelligent adaptations of the system could fulfill species and individual specific needs and preferences [13,15].

The tangible interaction approach could be used not only for orangutans but also for other species of animals with the ability of object manipulation, or in which the use of objects is among their preferred interactions with the environment, e.g., other species of primates, elephants, big cats, etc. Moreover, tangible interactions could not only be used with sound-based stimuli. Visual stimuli such as projections on the ground or walls could also be triggered by the system, these projections reacting according to the interactions of the animals with the tangible items. In addition, this form of interaction could be used to provide animals with control over their environment. Instead of using metaphors as buttons or activators, the use, movement or placement of objects could be mapped to changes over environmental features of the enclosure, such as lighting conditions or even playing sounds or movies if it is found that the animal would like to have this option. Allowing animals to have control over their surroundings in this kind of enclosures is one of the keys to improving their welfare.

Collaborative activities with zoo visitors or remote interactions with humans not present in the enclosure could also be envisioned using tangible metaphors to interact with the system. The use of tools as mediators of the interaction could be conceived as a way of connecting the human participant with the orangutan by relying on the common ability of both species regarding object manipulations.

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