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# Developing Zoo Technology Requirements for White-Faced Saki Monkeys

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## ABSTRACT

How early technology requirements are formed for animals involves asking humans caring for the animal to give requirements for them. For zoo animals, this is the keeper and other experts who work with the animal. This requirement gathering process is used as a method of forming user-centric designs for systems for animals. Yet little attention has been paid towards how to form these early requirements in zoos or whom to gather these from. Addressing this, we investigate how to construct technology requirements for the zoo housed animals, using white-faced saki monkeys as an instance. Utilizing the method of questionnaires, we gather requirements from zoo keepers and zoo visitors. Comparing and analyzing our results, we reveal how requirements for animal-technology in zoo contexts diverge and intersect. Our data indicates that these vantages mostly align; with the zoo visitors focusing upon the aesthetics and keepers concentrating on practicalities. Overarching these, we note how requirements in proxy for animals often involves a synthesis of complex motivations, user narratives, vantage points, and prior technology and animal experience that is irreparably intertwined within the requirement process. This paper builds upon requirement gathering methods for unconventional users.

## Author Keywords

Animal-Computer Interaction; Requirement Gathering; Zoo- Computer Interaction

## CSS Concepts

• **Human-centered computing~Human computer interaction (HCI)**

## INTRODUCTION

Animal-Computer Interaction (ACI) is a growing field that seeks to improve animal lives in various situations and environments through technologies [15]. These systems for animals range from technologies for working animals [33, 34], tracking and monitoring systems [7], and games and playful systems [10] ranging for farm animals [11, 37], wild animals [20], pets [40], and zoo animals [39]. Overall, these contexts and users, one central aim of the ACI field is to make these systems animal-centered by including the animal at the center of the design [26]. This is akin to user-centered design in HCI - which can broadly be described as how much influence the end-users have towards how a design takes shape [1]. With animals though, this shaping process and what constitutes user-centered design is more complex as animals cannot explicitly state their needs for systems to be modeled upon [43]. Nevertheless, often animals have been included, and maintained as a focus [1], within the user requirement gathering process of animal-technologies in one way or another [15, 43].

One particular focus of ACI is within zoo contexts. Traditionally, zoo-computer systems have provided a venue for studying the animals housed in zoo environments and their cognitive skills [39] and for husbandry purposes in assessing food-preference [19]. Recently, computer scientists have taken a new approach to zoo-technologies by using an HCI lens of investigating the design of, and the interaction mechanisms within systems used in zoo contexts [15]. This has been mainly in two forms: firstly, in creating games and enrichment systems for zoo animals [10, 12, 31, 40] and secondly informative installations and other interactive applications for educating the visitors of zoos [39]. Thus, technology usage at zoos increasingly has been used to enhance animal welfare, as well as visitor experiences and education. Yet, many zoos have limited resources in terms of money, time, and technology knowledge to invest in such systems [5].

When reflecting upon user requirements for zoo-technologies, these systems have further intricacies. In zoo contexts, there are multiple stakeholders involved who can feedback requirements on behalf of the animal, including zoo vets, zoo researchers and behaviorists, keepers, educators, PR teams, visitors, and curators. How zoos design systems that encompass all these stakeholders and requirements from the animals is messy where there is currently no formal method. Instead, habitually a variation of groups is consulted to give feedback informing requirements and focusing the design on behalf of the animal.

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Consequently, presently we do not know the impact that gathering from these different groups as proxies for animals has and how this transpires towards user-centeredness focus. This is especially nuanced and critical in two ways: firstly, animals are often vulnerable users relying upon this human-to-animal translation paradigm to get their needs met, and secondly, zoos often have little resources to invest in such systems. As a result, many zoo-technology systems encounter challenges in the adoption of systems, such as animals breaking novel systems [5] or zoo visitors rejecting technology devices [39] pointing towards inadequate requirements. These kinds of problems with adopting technologies can prevent actualizing the potential benefits of these systems and thus hinder improvements to animal well-being, turn off visitors, and result in wasted resources.

Grounding current zoo-computer interaction work, this paper investigates how requirement gathering for animals varies across different user groups for zoo contexts. This is done through a case study approach at Korkeasaari Zoo in Helsinki, Finland with one group of animals, the white-faced saki monkey. We use the questionnaire method to gather requirements from two frequently used user groups: keepers and visitors [5, 40]. We ask these groups questions pertinent to early requirements [1] upon recent zoo-technology trends, around how technologies should look, what goals the system should have, and how they wish the interaction to be designed. We frame this upon the following questions:

**RQ1:** What are the requirements that zoo keepers and visitors have for systems with white-faced saki monkeys?

**RQ2**: How do these requirements differ/align between the zoo keepers and visitors towards zoo-technology design guidelines?

Based on our findings, we firstly contribute a set of preliminary requirements and their encompassing method for our zoo context, relevant for those beginning to design technology for zoo animals. These requirements draw from the trends and commonalities emerging between visitors and keepers; who often have aligning requirements for animal technology. Yet these requirements diverge in terms of how they want the technology to look like and what they value in animal-systems. Secondly, we then speculate upon people’s (keepers and visitors) roles when forming requirements for animal-systems. Here we highlight how requirements gathered from humans for animals are intertwined within the person's narrative, experience, and motivations. These findings are of interest to those working with complex users towards early requirement gathering.

## RELATED WORK

Zoo as an environment for animal technology offers a myriad of opportunities to develop systems for different animals and various use cases. The goals of zoos have evolved from being mainly recreational to ensuring primarily the welfare of their animals, to educate and influence the attitudes of the public to aid conservation efforts, and to conduct research that helps in fulfilling these goals [3]. All these objectives have the potential to benefit from the use of technology [15]. Furthermore, these goals of fostering animal well-being and human-animal connections are shared and form the foundation of, the ACI community [26]. Additionally, technology can be used to provide animals with variable and appropriately challenging enrichment and ways to control their activities and environment [5, 23, 28] and insure their natural behavioral competencies [6].

As an expected consequence, recently there have been developments to make enrichment the primary goal of designing computer technology for zoo animals, rather than focusing on traditionally using computers for cognitive testing or husbandry [39, 40]. Enrichment systems currently designed for zoos are frequently formed of touch screens and tablets typically for primates [4, 13, 29, 42]. Other systems designed for non-primate animals tend to focus on food or foraging behaviors used in multiple zoos worldwide [22, 24]. However, a common issue with computer systems made for animals is that they have often been designed from the human point of view and using technologies adapted from human use [25] such as tablets [36]. While primate-proof screen systems have been developed to be used in zoos [27], novel systems beyond this suffer from context problems such as broken equipment or interfaces that are difficult, or not being ideally intended, for the animals to use [5]. Thus, while technologies have and are being employed in zoo contexts, these are not perfect with further research needed upon their formation.

### Requirement Gathering in Animal-Computer Interaction

One way to form technology around the user is through early requirement gathering. Requirement gathering approaches for animals are often based on existing HCI requirements elicitation methods [43, 44]. These include considering the species-specific features, behaviors, natural ways of interacting with objects, and gathering from people on behalf of the animal [21, 34]. In ACI this is often elicited through observing the animals for which the system is designed and the context in which the technology would be used [33]. One approach for species-centric design is ethnographic methods which evaluate the situation through viewing the animal and enrichment activities within the enclosure [10]. In some cases, also a more participatory approach has been taken by prototyping with the animal(s) to uncover their preferences for interfaces, materials, or interaction methods [34, 41].

Regardless, animal participation within zoo-technology contexts is challenging due to the non-domesticated nature limiting the human-animal relations needed for participatory approaches as well as factors such as lack of resources or interferences from other practical circumstances like procreating animals or introducing new individuals [30]. Instead, the key requirement gathering method used with zoo-animals is that of asking specialists and/or someone who works closely with the animal to feedback on behalf of them. This process is not dissimilar to the role adults take in child-computer interaction systems with very young children [32]. Requirements gathering in proxy in ACI ranges from consulting caretakers of the animals such as their keepers [12, 39] or owners [16, 17, 33], to consulting animal welfare and behavioral specialists [45]. Humans also explore through design [10, 18, 44] but this often does not involve the animal. This results in the requirements in animal-technology often being gathered from various human roles across several projects.

### Requirement Gathering in Zoo-Contexts

Animal-technology systems for zoos have been primarily focused on designing for apes and elephants. Enrichment systems designed for apes include tracking tangible objects within the enclosure with a Microsoft Kinect to allow orangutans to generate sounds [31]; iPad games for orangutans [40]; digital installations with a projected, motion tracking based interface for orangutans [35, 40] and a tangible feeding puzzle for gorillas [12]; French et al. [8-10] have iteratively developed an "elephant radio" consisting of an interactive cognitive and acoustic enrichment toy for elephants.

| | Keeper | Expert | Visitor | Researcher Observation | Prototyping | Previous Technologies | Previous Enrichment |
|---|---|---|---|---|---|---|---|
| Pons et al. [31] | x | | | | x | x | |
| Gupfinger & Kaltenbrunner [14] | | | | | x | | x |
| Webber et al. [39] | x | x | | x | x | x | |
| Gray et al. [12] | x | x | | x | | | |
| French et al. [8-10] | x | x | | x | x | | |
| Scheele [35] | x | x | | | | x | x |

**Table 1. Requirements gathering methods used in literature.**

Requirements for these systems when initially built have been gathered mostly from people working with the animals (keepers and welfare specialists) as well as researchers observing the animals, their previous technologies, and/or enrichment usage (Table 1). Gorilla Game Lab [12] and projector installation by Webber et al. [39] for orangutans were built primarily based on observations and collaboration with keepers and zoo staff, including workshops and interviews. Scheele [35] based their projector installation on interviews with keepers and experts, as well as knowledge from existing enrichment methods, other related works, and feedback from the testing sessions. The elephant toy design process of French et al. [8-10] included additionally prototyping with the animals to find out how they reacted to different interaction and feedback mechanisms. Pons et al. [31] primarily used collaboration with the keepers by making design decisions based on observations from previous enrichment experiences. Webber et al. [39], Gupfinger & Kaltenbrunner [14] and Pons et al. [31] do mention using prototyping but do not state how this was done or its implications towards requirements and the designs/systems created. Consequently, as can be seen from Table 1, requirement gathering for zoo-animals is often based upon multifaceted combinations. Furthermore, all these approaches tend to ignore the visitors' perspective (RQ1).

### Zoo Staff and Visitors Role in Animal-Technology

Besides enrichment goals for animals, technology has also been used in zoos for educational purposes. Educating zoo visitors is one of the main goals of zoos, where 94% of the visitors expect this [3]. Additionally, recent guidelines recommend employing new technologies to facilitate learning and increase engagement [38]. However, many existing solutions in zoos provide information for the visitors without directly including the animals [5, 40], except when the technology allows observing the animal via video [40].

Similarly, when systems have been designed for animal enrichment the visitors' point of view has often not been considered as a central factor [12, 31]. Furthermore, there have been indicators that technology usage in zoos can be perceived negatively by the visitors. As Clay et al. [5] note, people can reject or be distracted by technologies, which may detract from their experience and connection with the animal [40]. For this reason, and to maintain naturalistic appearances in exhibit space, it is a common practice among zoos to give computer enrichment off-exhibit. Yet Perdue et al. [28] and Webber et al. [40] also reported increased positive visitor attitudes, increased empathy, and increased time visitors spent by the enclosure when visitors see animals using computer systems. Thus, even though systems are primarily used by animals, they affect the visitors' experience and education [5] and thus how technology is used and deployed. Consequently, giving little consideration to the visitors' perspective seems counterproductive to the central aim of educating people and influencing their attitudes toward animals and their environment.

Unlike zoo visitors, zoo staff, consisting of experts and keepers, are habitually consulted during zoo-technology formation (Table 1). Like visitors, zoo staff also often have positive attitudes towards animal technology usage [5], but for them, there are also several different challenges in adopting these technologies. These include the difficulties setting up or maintaining the technology or lack of technical skills within the zoo, high cost of the technology, and zoo staff not having enough time [5]. Likewise, the number of zoo staff and their availability is often limited compared to zoo visitors [5].

Here we seek a more comprehensive approach to requirements gathering that holds the potential to help mitigate some of these challenges. Prior work suggests that visitor expectations and needs do not always align with the ones of the zoo as an institution and of the staff working there [5]. Yet, no research has been conducted on how these potential differences play out when it comes to the building requirements for zoo technology and how these affect the curation of system goals. We propose then that explicitly considering the perspectives of all the stakeholders, the zoo staff, as well as the visitors, could be expected to help design technologies that not only enrich the life of the animals but also enhance the visitors' experience and help the zoo in fulfilling its educational and animal welfare goals (RQ2).

## METHOD

To investigate how the keepers' and visitors' requirements for zoo technology would look like and in what ways they might differ, we designed a questionnaire around the key themes identified from related literature (noted above). We used the questionnaire method due to its ease to distribute to both keepers and visitors and to get comparable quantitative data as well as qualitative data in form of open questions. As visitors were often busy at the zoo, and keepers busy at work, this method also fit the confounds of our participants in situ. It is in this way that our method allowed us to capture the most amount of data, as unobtrusively as possible from a range of sources.

In our questionnaire, the participants were asked to consider a particular animal species, the white-faced saki monkey, living in the Amazonian house in Korkeasaari Zoo, Finland. A case study of one animal provided a suitable approach to focus on the differences and trends of the different human stakeholders. The white-faced saki monkey was chosen due to it being a novel species for ACI but common in zoos in general, meaning our results are highly applicable and can later be iterated upon. To situate the questionnaire, we asked our participants to answer the questionnaire based on a scenario that we are developing some kind of computer technology for this particular monkey and wanted their input.

### Questionnaire Formation

The questionnaire included a total of twenty-two questions: questions about demographics and visitor experience, seven Likert scale questions, four of which had an additional optional open question for elaboration, three selection questions, and three open-ended questions. The complete questionnaire can be found in supplementary files. Demographic information (age and gender) was asked (Q1, Q2) to find out potential differences between demographic groups and ensure a relative sample. Especially of interest were children that constitute a large proportion of zoo visitors and might have different interests than adults. To record the visitors' previous experience and to see if this impacted the results, visitors were also asked how often they visit the zoo (Q3). We also asked if they had visited the white-faced saki monkeys (Q4) or attended the daily guided tour in the Amazonia house where the species lives (Q5). These questions allowed us to assess how familiar the visitors were with the animal and how well their answers were grounded in the real-world experience of observation. In the same vein, keepers were asked whether they had, or currently worked with the white-faced sakis and if so, for how long.

There were five five-point Likert scale questions (ranging from "*Very important*" to "*Not important at all*") assessing how important people found different use cases (Q6 health monitoring, Q7 enrichment, Q11 learning something from the animals' use of the technology). These use cases reflect the goals of the zoo-animal welfare and visitor education forming goals of prior ACI work [12, 39, 40] and zoos alike [3]. Additionally, we wanted to investigate how visitor attitudes coincide with these when it comes to technology use as this aspect had been underexplored.

Participants were also asked how important it is that they can see the animal using the technology (Q9). This question could reveal a potential point of conflict, as previous work has been divided on whether visibility to visitors is a priority or an important factor [39, 40] or not [12]. Finally, there was a question about how important the participants find that the animal can use technology without training from humans (Q12). The question of training, and whether designers should build intuitive interfaces and/or train animals to use interfaces, has been a point of discussion in ACI [17] and animal enrichment technologies [12].

Additionally, two five-point Likert scale questions ("*Positive*" to "*Negative*") were asked upon how people feel about human-like aesthetics technology for animals such as tablets (Q14) and systems that look artificial (Q15) at the zoo. We asked this since there have been concerns over potential conflicts between naturalism and technology at the zoo both in terms of look and function [27, 40]. Two selection questions were asked about placement (Q16) and movability (Q17) of the technology to see how participants would imagine the animals' interaction with the technology on a high level. Furthermore, previous systems for zoo animals have often been fixed to the enclosure elements or outside the enclosure [12, 40], and we wanted to see how visitor and keeper attitudes relate to these kinds of solutions. We also asked a selection question on whether people would like the technology to enable interaction with the animal (Q18). Some zoos for instance provide apes with a chance to spray water on the visitors [5]. Regardless, facilitating human-animal interaction in the zoo has not been a priority in ACI, with more focus on human-to-pets [25] and animal-to-animal [18] interactions. However, since successful interaction without compromising animal welfare could increase visitor engagement and empathy while providing animals with enrichment [5, 23], we included a question to assess attitudes toward the topic. This is not to say though that this would not have to be delicately balanced to maintain normal patterns of social behavior and not impinge on welfare – but that we wanted to see if this was valuable to both keepers and visitors. Lastly, we asked three open questions about what kind of technology the participant would like for the animal (Q20, Q21) and what kind of technology they thought we should avoid (Q22). Questions 7, 9, 12, and 18 had open-ended follow-up questions allowing the participants to elaborate upon their responses.

### Questionnaire Distribution

The questionnaires were distributed in paper form to the visitors next to the white-faced saki enclosure in the tropical house of Korkeasaari Zoo for six days over one month. We approached zoo visitors next to the enclosure to get answers from people who had seen the white-faced saki and allow people to answer while or right after observing the animal. We were also present to answer any possible questions. Participants were asked to fill out the questionnaire on paper and no incentives were offered. Many zoo visitors declined due to lack of interest, time, or having small children to watch over. Participants did not tend to ask questions about the questionnaire, but some asked about the project or were interested to talk about the topic in general. For keepers, the questionnaires were distributed through the curator at the zoo and thus were asked to fill it out by their superior.

### Participants

Most people were quick to answer the questionnaire and left all or most of the open questions unanswered. People also often liked to fill out one questionnaire together as a family, especially if they were with children. There were in total 52 visitors who filled in the questionnaires, and 4 keepers. These keepers all worked directly with the white-faced sakis varying from 4 months to 3 years. All of the keepers were female adults (aged 20-65). As for the visitors, 52% (27/52) were male, 42% female (22/52), and three questionnaires were filled out by a group consisting of both genders. Most of the participants were adults aged 20-65 (79%: 42/52), with one participant under 13 years, one over 65 years old, and six responses from teenagers. For two participants (4%) the visit was their first to this zoo – mostly participants reported visiting once a year (33%, 17/52) or more rarely (50%, 26/52). Four participants responded they visit about once every six months, and one said once in three months. Nine of the participants (17%) responded that they had not visited the white-faced saki while at the zoo, while 63% (33/52) had seen the animal. Additionally, 10 participants (19%) were uncertain if they had visited the white-faced sakis and selected "*I don't know*". Only two participants had participated in the free mini guided tour organized by the zoo once a day. Thus, most of our results are based on lived experiences, from adults who typically visit the zoo once per year or less.

### Analysis

Analysis of the questionnaire results was conducted by calculating mean (M), median (MED), and standard deviation (SD) for scaled questions. Initially, the data was cleaned for missing answers and scaled questions also "*I don't know*" answers were excluded.

| Suggested Theme | Explanation |
|---|---|
| 1. Health | Improving/ monitoring the health of animals. |
| 2. Enrichment | Some form of enrichment. |
| 2.1 Puzzle & Game | Implementing games, puzzles, or cognitive enrichment. |
| 2.2 Food | Food related enrichment. |
| 2.3 Environment | Environmental enrichment e.g. systems that change the ecosystem. |
| 2.4 Choice & Control | Providing some form of control over their environment or life. |
| 3.Video & Camera | Enable people to view the enclosure or a video stream from the animal's point-of-view |
| 4.Human Technology | Human-like technology other than cameras, video, tablets, screens or keyboards |
| 5."Something Good" | Vague suggestions along the lines of "*just anything good for the animal*" |
| 6. Interaction with People | Technology that would enable interaction with the animals. |
| 7. Learning About the Animal | Systems that would enable learning about the animal and/or their behavior and reactions. |

**Table 2. Themes identified from the open questions as beneficial technologies for zoo contexts.**

The participants' open-ended answers were analyzed through a coding schema once for technology upon what to avoid and one for technology wanted. This was first done by reading through all of the ideas and labeling concepts and themes that emerged from the answers. Two researchers then coded these groups separately and came together as a group to analyze each other's coding following prior methods [2]. Since the fidelity of suggestions in the answers ranged from very general "*something that respects the animal, on the animals' terms*" (P31) to very specific suggestions "*snake game*" (P33), the initial encoding was too high-level categories that appeared in the answers.

| Suggested Theme | Explanation |
|---|---|
| 1. Unnatural | Technologies that are unnatural in their usage of encouraging unnatural behaviors |
| 2. Human Entertainment | Systems that priorities human entertainment. |
| 3. Physically Affects the Animal | Technologies that are attached to or embedded within the animal such as implants, microchips, or attached devices. |
| 4. Adverse Consequences | Anything that can be regarded as an adverse consequence for the animal. |
| 4.1 Stress | Technologies that cause stress for the animal. |
| 4.2 Frustration | Technologies causing the animal frustration. |
| 4.3 Addiction | Technologies that cause the animal to have addictions. |
| 4.4 Breakable | Technologies that are easily breakable. |
| 5. Too Easy | Technologies that are too easy for the animal. |
| 6. No Technology | All technologies are bad for animals and should be avoided |
| 7. Cannot be monitored | Technologies that do not allow you to monitor the animals' use of it. |

**Table 3. Themes identified from the open questions of technologies that should be avoided in zoo contexts.**

More specific suggestions were then grouped to fit a combination of our higher-level category codes. For these specific suggestions that recurred frequently within these groups, more refined categories were added, such as *Adverse Consequences* separated into *Stress*, *Frustration*, *Addiction,* and *Breakable* for zoo-technology systems to avoid. Tables 1 and 2 present our final themes.

## RESULTS

The results indicate that when it comes to the importance of different purposes and functional aspects of technology for the white-faced saki monkeys, the views of keepers and visitors seem to be well aligned. We found no large differences between these groups apart from upon artificial-looking technologies (Table 4). In general, the keeper responses had less variation and they considered all the aspects slightly more important than the visitors (Table

4). The animal-centric uses of supporting health monitoring and enrichment were considered the most important aspects of both groups and also had the least variation in the results (Table 4). Visitors felt that technology enrichment could be important to "support natural behaviors" (P2) or "help preserve" these (P26), as these have "intrinsic value" (P15), and technology could be "*making life "easier" for the animal*" (P19) through "*helping the monkey*" (P37) "feel comfortable" (P49).

The human point of view of seeing the monkey using the technology and learning something by watching them use it was regarded as least important, while the aspect of not requiring training requirement fell in between. Visitors often did not want the animal to be trained as this was not "*natural*" (P5) and felt this was "*unnecessary*" (P10) and that the animal could have "*more "private time"/peace without teaching*" (P26), or that training would get the animals to "*behave in a way that is atypical for them*" (P46) resulting in a "*cheap circus trick*" (P52). Visitors who wanted animals to be trained thought training this could provide "*learning*" (P19) and gaining "*skills*" (P29), as part of "*stimulation/enrichment*" (P24) and felt that by training this would "*make it easier for everyone…more practical and cheaper*" (P37). Keepers felt that training is important so that the "*animal gets the most out of the system when it is used. A certain level of training would be good to avoid frustration*" (Keeper1).

| | Visitor | | | Keeper | | |
|---|---|---|---|---|---|---|
| | M | MED | SD | M | MED | SD |
| Health Monitoring | 4.48 | 5.0 | 0.60 | 4.75 | 5.0 | 0.43 |
| Enrichment | 4.59 | 5.0 | 0.63 | 5 | 5.0 | 0 |
| Seeing the animal's usage | 3.31 | 3.0 | 1.03 | 3.67 | 4.0 | 0.47 |
| Learning about the animal | 3.63 | 4.0 | 1.03 | 4.25 | 4.0 | 0.43 |
| No training required | 3.98 | 4.0 | 0.96 | 4.25 | 4.5 | 0.83 |
| Human-like aesthetic | 2.89 | 3.0 | 0.87 | 3.75 | 3.5 | 0.83 |
| Artificial-like aesthetic | 2.53 | 3.0 | 0.96 | 3.75 | 3.5 | 0.83 |

**Table 4. Means (M), Medians (MED), and Standard Deviations (SD) for goal and look of zoo-technologies for white-faced saki monkeys. Scale 1-5: 1 being "*Not important all*"/"*Very negative*", and 5 being "*Very important*"/"*Very positive*".**

Visitors commented that they believed that seeing the animal using the technology was not important as "*it's more important that the animal benefits from the technology*" (P2), "*benefiting the animal*" (P39), that "*it's not for me but for the animal after all*" (P10) and that seeing was "*not necessary*" (P24). However, these answers also indicated that instead of "*hear/reading info*" (P2) or "*maybe a short video could suffice*" (P10). Visitors that wanted to see these interactions felt this would be "*entertaining to watch*" (P19) or "*educational to see*" (P35), with a child commenting that they wanted to see and "*let the monkeys play Fortnite*" (P49). These answers also contained caveats that this should only be possible if it did "*not disturb the animal*" (P35), being "*inconspicuous*" (P37) where the "*health (also mental) of the animal are the most important thing*" (P19). Keepers felt that it was not important to directly see the animal using as there "*was the possibility of video recording*" (Keeper1).

Regarding the looks of technology for the white-faced sakis, the keepers and visitors seemed to have differing opinions especially in terms of artificial-like aesthetic (Table 4). The keepers reported more positive attitudes ranging from "*neutral*" to "*very positive*" for technologies that looked both human-like and artificial and not belonging to nature. Visitors' views were more diverse: many of which fell within "*negative*" and "*very negative*" (27.5% of all answers for human-like and 49% for artificial-looking. Furthermore, visitors seemed to view artificial-looking technology more negatively than human-like, while keepers had similar views on both categories (Table 4).

| **Placement** | **Visitor** | **Keeper** |
|---|---|---|
| Inside | 26 % | 25 % |
| Outside | 23 % | 0 % |
| Does not Matter | 47 % | 25 % |
| Other | 5 % | 50 % |
| **Movable** | | |
| Fixed | 12 % | 0 % |
| Moveable by Human | 16 % | 33 % |
| Moveable by the Animal | 49 % | 33 % |
| Moveable by the Human and Animal | 2 % | 0 % |
| Does not matter | 26 % | 33 % |
| Other | 2 % | 0 % |
| **Interactive** | | |
| Yes | 63 % | 0 % |
| No | 28 % | 0 % |
| Does not matter | 26 % | 100 % |

**Table 5. Percentage of answers for placement, movability, and interaction for technology for the white-faced sakis.**

Additionally, questions about the placement and movability of technology devices had slight differences between visitors and keepers (Table 5). The placement (inside or outside of the enclosure) didn't converge to any definite option for visitors. Keepers equally did not have strong opinions, with two out of four stating that it depends on the type and use of the technology and the practical aspects ("*other*" option' Table 5). Movability on the other hand divided the opinions of keepers, yielding different responses from each. Among visitors, the most popular option on the other hand was that the device should be movable by the animal themselves. The other option suggested by visitors was it depended upon the situation.

Certainly, the most divisive answers were upon the question of whether the technology should allow interactions between the visitors and the animals (Table 5). All keepers felt this aspect did not matter, expressing concerns that this would be "*difficult to implement so that the welfare is taken into account*" (Keeper2), stating that instead of that there "*is already interaction with the keepers and the troop interacts with each other*" (Keeper3) so they do not need further human contact. One keeper stated outright that interaction with visitors should not be possible: "*not with the visitors, but preferably with each other*" (Keeper2). Over half (63%; 27/43) of the visitors on the other hand would like to have interaction-enabling technology (Table 5). Visitors stated they would like this interaction to "*communicate with the animal*" (P8, P13), to help them "*know what it feels like to be an animal, how the animal feels*" (P16), "*to make [the animals'] needs visible*" (P26), to "*talk to/with the monkey*" (P32), and "*to lure/catch their attention*" (P37) towards "*bringing them to sight*" (P44). Visitors that did not want this interaction (28%; 12/43) felt that this would not "*enable a life that is natural as possible*" (P2) or be a "*natural match*" (P17). Visitors who felt it *does not matter* or selected *other* did not explain.

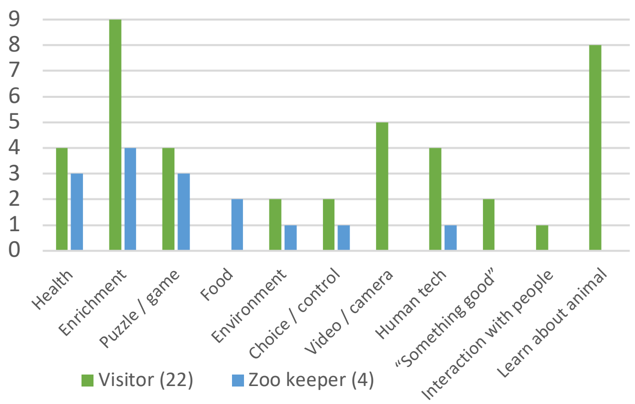


**Figure 1. Visitor and Keeper suggestions on what to develop regarding technologies for white-faced sakis.**

The final questions were open questions upon future suggestions and what technologies should be avoided with white-faced sakis (Figure 1 & 2). The themes most often mentioned by visitors were technologies supporting animal enrichment or that would enable learning something about the animal (Figure 1). For supporting the animal, visitors frequently mentioned technology should "*improve their environment*" (P24), "*reduce stress and tension*" (P4), "*enrich its life*" (P12) and "*respects the animal, on the animal's terms*" (P31). Visitors wanted to learn about the animal through "*1st person cameras*" (P8), "*a screen that demonstrates how the animal sees its environment*" (P16), and "*a screen that shows Sakis tricks it can make*" (P36). Other themes mentioned frequently were health related technologies (e.g. "*technology that lets the monkey tell if it is hungry*" (P22), games or puzzles (which falls under enrichment) e.g. "*choosing colors*" (P4), video or camera systems enabling seeing the animal or its point of view, and different human technologies such as tablets or screens for the animals' use.

Keeper responses on the other hand were very much focused around health and enrichment technologies: "*something enriching that would tap into curiosity and exploration*" (Keeper 1), "*possibility for the animal to select different options to "ask" animal's opinion e.g. lighting, sounds*" (Keeper 4), "*health monitoring e.g. heart rate, sleep quantity, blood pressure, amount of exercise*" and "*welfare monitoring devices e.g. movement tracking, sleep duration and quality, weight*" (Keeper3) (Figure 1). Within enrichment, specific suggestions included especially puzzles and food related systems such as "*automated puzzle feeding...recognizing individuals*" (Keeper1).

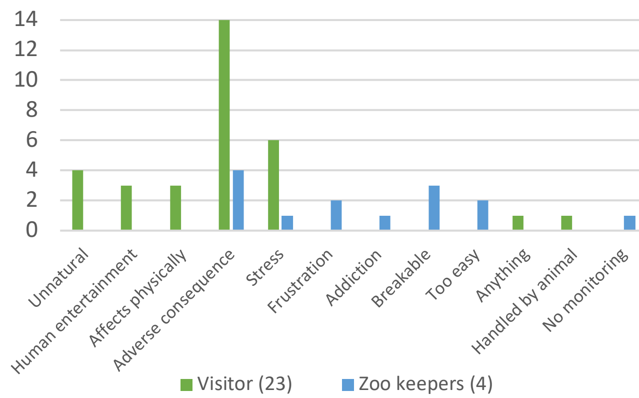


**Figure 2. Visitor and Keeper suggestions on what to avoid regarding technologies for white-faced sakis.**

On the question upon what should be avoided when designing/building technology for the monkeys, the most common responses from the visitors were general key negative terms such as "*stress/ stressful*" (P6, P15, P32), "*harmful*" (P16, P45, P47), "*disturbs/ too disturbing*" (P15, P34) and "*invasive*" (P29). Additionally, suggestions were made to avoid unnatural things e.g. "*technology that changes the natural behaviors*" (P49), devices that would physically affect the monkey such as implants or microchips; "*microchips, may not be good for the animal, rather have external technologies*" (P37), "*anything that physically directly affects the animal like implants or such*" (P24) and anything designed (primarily) for human entertainment "*this should always be secondary and carefully selected*" (P52). Especially for animals, it was seen as important not to give human technology that "*would make them human, so that they don't play Clash Royale all day*" (P13). A visitor additionally suggested that anything that could be "*handled by the animals*" (P45) should be avoided. Another visitor took this view further stating that we "don't have to force technology everywhere. Just let the monkeys be*"* (P23), suggesting avoiding all technology.

Keepers were again more unanimous and specific in their responses; all four stated some kind of potential negative effects (Figure 2) but likewise focused upon "*stressful for the animals*" (Keeper1). Instead, the keepers wanted potential devices to be durable and not "*easily breakable*" (Keeper1, 2, and 3) in case the monkeys "*chewing on things*" (Keeper2) especially "*loose parts (could eat something dangerous)*" (Keeper1). Equally, the keepers wanted to avoid anything "*too addictive, too easy*" (Keeper4) and "*too simple*" (Keeper 3) where systems should "*avoid frustrating the animal*" (Keeper4) and not be "*fattening*" (Keeper1) if it includes food. Other unfavorable things mentioned were addiction, and systems not to "*punish the animals*" (Keeper4) if used incorrectly.

## REQUIREMENTS

Based on the above results from keepers and visitors, we formed requirements for zoo-technology for white-faced sakis (Table 6). The requirements are based upon our questionnaire results grouped into Common Requirements (CR) shared by both visitors and keepers, visitor requirements (VR), and keeper requirements (KR). These were formed through key themes identified (Figures 1 & 2) that had >50% and aspects rated as important (Table 4 & 5) from each grouping.

| Common requirements | |
|---|---|
| CR1. Enrichment | |
| CR2. Health | |
| CR3. No negative effects | |
| CR4. No training required | |
| CR5. Can see the animal using | |
| **Visitor** | **Keeper** |
| VR1. Learn something about the animal | KR1. Not easily breakable |
| VR2. Not artificial-looking | KR2. Not too frustrating |
| VR3. Human-animal interaction | KR3. Not too easy |
| VR4. Movable by the animal | KR4. Not addictive |
| | KR5. Needs to be monitored |

**Table 6. Requirements identified from the results grouped to common, visitor, and keeper requirements. Ordering within the group roughly indicates descending priority.**

## DISCUSSION

Over the previous pages, we have used the method of questionnaires to gather keepers' and visitors' requirements upon zoo-technologies for white-faced saki monkeys. From these, certain themes were noted towards the interactions, design, and usage of zoo-technology systems. The findings of our study are relevant to two domains: firstly, towards how to form early requirements for animal users in zoos, and secondly towards the multifaceted roles that people play when forming these requirements.

### Requirements for Animals

Drawing from our results towards RQ2 upon requirements, it is evident that many of the zookeepers' and visitors' requirements aligned (Table 6) unlike prior work [5]. Though, the visitors often answered with a more generalizable response whereas the keepers often had very focused and practical answers. We suspect this is due to the keepers having more experience and knowledge of the species and seeing technologies as assisting or potentially complicating their day-to-day role. The keepers' views additionally were habitually aligned, while the visitors varied across the spectrum even if focused upon the same topic. For instance, the keepers' direct applications frequently focused on welfare technology for the animals or for them to monitor the animals. Visitors on the other hand had a more varied view of welfare that often encapsulated their visit and viewing experience.

One key area of incongruity is that the visitors had a more negative view of technologies that looked artificial whereas the keepers did not (Table 4). Here specifically visitors were primarily concerned about the negative impacts that technology could have upon welfare such as stress and addiction. Overall, the visitors' views aligned with the finding of Perdue et al. [28] that technology should be used, with our results shedding more light upon their motivations. Additionally, while zoo visitors noted health, which forms part of welfare, as one of the potentials focuses for animal-technology (Table 4), very few suggestions were given towards systems for this (Figure 1). Instead, the most frequent recommendation for potential technologies, besides enrichment, was to enable understanding the animal better through their technology interactions (Figure 1). Yet, learning about animals was rated as one of the least important aspects, especially by the visitors (Table 4). Keepers did rate learning as important property, even more so than visitors, however, their suggestions did not reflect upon this – possibly because educational aspects may not be a central part of their responsibilities. Moreover, visitors wanted technology-mediated interactions with the animals (Figure 1). We suspect that the keepers did not mention this aspect as they already have/had interactions and, as cited, felt that their interactions with the monkey were already sufficient for the monkeys. This is despite this being a learning opportunity as noted prior [28, 39, 40].

From a method standpoint and when looking at the animal requirements, our results indicate the value in having both open ended and scaled questions to get a fully reflective view. While the closed-ended questions attracted more responses, the comments that were given to the open-ended questions provided valuable further insight into people's attitudes and reasoning for their views. We also found that requirements for zoo-animals can be gathered from either the visitors or zoo keepers with analogous aligning results. More so, by gathering from these two user groups we present a more reflective and well-rounded vantage that encapsulates multiple vantage points from those involved in some way with the technology system. To speculate from this, it could be that when it comes to suggestions for technologies, visitors might be able to provide more out-of-the-box ideas since they are not constrained by having intimate knowledge of the animals and limitations of the environment. Furthermore, as noted in our introduction, zoos and their staff often have limited resources, funds, and/or time to conduct a study like ours. As our participant numbers show, there are frequently more visitors than keepers who often give a more detailed narrative. Therefore, although visitors are often excluded from zoo-technology systems (Table 1) we highlight this user group as a potential source towards gathering animal requirements for systems.

### Dual Roles People Play in Animal Technologies

Reflecting upon designing technology for animals, we found that people who work closely with the animals typically have split roles. On one hand, they interpret the animals' needs while also having their own requirements for computer systems. These issues are especially prominent in zoo contexts where numerous stakeholders exist when forming technology systems. While the individual needs of people we questioned are undoubtedly different due to their different roles and tasks within the zoo - our results show that when it comes to the central themes concerning animal welfare they align.

Moreover, when it comes to the requirements themselves that humans have for zoo-systems there are additional divisions. Many of the keepers' requirements are critical for the animals' safety and to ensure the system is feasible in practice and thus must be considered. Visitors on the other hand often have requirements that are not necessary from the animals' or staff's point of view. However, visitor education and engagement are also important goals for zoos, and technology usage can contribute to their realization. Hence, considering the visitors' needs when feasible can provide additional value, even when the animals are the primary users. Thus, even though accommodating the visitors' desires may not directly contribute to the animal-centered perspective of the animals using the particular system, it can still advance animal welfare and awareness on a higher level through education and increased interest.

Overall, in the questionnaire visitors had a more human-centered perspective compared to keepers, in the form of their desires to learn and understand the animal better. This example shows how the dual multifaceted role of humans can have a different and conflicting focus depending on the position and perspective that the stakeholder takes. This multilayer perspective is a synthesis of complex motivations, user narratives, vantage points, and prior technology and animal experiences that become irreparably intertwined within these requirements. Reflecting over these compartments, keepers were divided in their facets of animal and their own needs, while visitors were more prone to overlap these both in motivation (who the technology is for) and the goal of the system (purpose) slanted towards what they find interesting and want for themselves.

## FUTURE WORK AND LIMITATIONS

The main limitation present in this work is the limited number of keepers and that zoo visitors who were not interested opted out of the questionnaire. This drawback is an outcome of the real-world environment where only limited keepers are often present and zoo visitors busy. Future work could involve multiple employees at various zoos, including zoos which currently have primate computer enrichment, to have a larger sample size and more comparative of contextual factors. Furthermore, while we highlight that the personal lens may affect the narrative given by our participants, we acknowledge that there are both locational and cultural factors at play that have yet to be generalized. Looking towards the future, we plan to use our requirements to build systems for the white-faced sakis and iteratively develop these over various animals, technologies, and locations. Moreover, it would be pertinent for future researchers to also investigate individual and specialized questionnaires for each stakeholder group's concerns in-depth to supplement the larger narrative.

An important potential part of this process is to, as discussed, not to just take the requirements at face value but deeply question the bigger narrative that they are placed within. Over time this will situate the ACI field while also emphasizing the potential for other disciplines in HCI. For while these dialogues around animal technologies, and forming their requirements for these systems hold true, these same divided upon roles have been noted in HCI. While this study contributes towards new understandings in animal-technologies for zoos, the discussion around proxy requirements is relevant for both those in ACI and HCI.

## CONCLUSION

As more zoos adopt, form, and integrate technology systems for both humans and animals, we speculate that the requirement gathering process will become an important facet to create user centered design. Gathering requirements from humans on behalf of animals is not a new occurrence but is often implemented in animal-technologies as a way to focus upon the design upon the animal user. In this paper, we use a questionnaire method with both keepers and zoo visitors to explore what their requirements are, and further how these align using white-faced saki monkeys as a case study. With four keepers and fifty-two visitors' responses to our survey, we evaluate the placement, movability, interactivity, goal, and aesthetics of animal-computer systems. These are synthesized into common, keeper, and visitor requirements. Here we found that the goal of the system often aligned around enrichment and health. Visitors were more concerned about learning and the look of technology, wanting systems to support human-animal interactions and grant the animal autonomy. Keepers on the other hand were more concerned with the practicalities of technology systems, regarding breakability, not being too frustrating, addictive, or easy, wanting systems to monitor the animal. From our work we suggest that these requirements are multifaceted, often drawing together the users' vantage. As our guidelines highlight, we need to foster research to investigate both the motivation and lens of the requirements.

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