



Interactive technology and human–animal encounters at the zoo

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ABSTRACT

In this paper we investigate social dimensions of technology use in human–animal interactions, through a study of interactive systems at the zoo.

Zoos are a familiar place for encounters between humans and non-domesticated animals. Accordingly, we examine zoos as a significant site to extend research into animal–computer interaction (ACI). We present a case study that examines the deployment and use of new digital technologies that intervene in, and influence, human–animal relationships.

The paper reports on interactive systems in use at Melbourne Zoo. The study investigates the use and impact of technology in the course of human–animal encounters, including how human use of technology in this setting shapes encounters in subtle ways. We examine five interactive systems used by visitors (*Digital Signs* and the *Zoopermarket*), by zoo personnel with visitors (*Educator Screens* and *Volunteer iPads*), and by zoo personnel with animals (*Apps for Apes*).

Our work draws broad insights for the design and understanding of animal–human–computer interaction at the zoo, as a catalyst for further research into this site of considerable significance to animal–computer interaction. We identified four key themes in the ways that interactive systems are intervening in human–animal encounters at the zoo. Firstly, interactive technology at the zoo risks distracting from visitors' encounters with animals. Secondly, the appearance and use of technology moreover runs counter to expectations of naturalistic zoo landscapes. Thirdly, interactive systems however offer opportunities to enhance important aspects of visitors' experience of animal encounters, and to widen the temporal and spatial dimensions of the encounter. Finally, we interpret these insights by examining how technology is used in the context of interactions between numerous human and animal actors, and in a setting impacted by complex social and organisational forces. From this, we identify the need for ACI to consider technology use by diverse people and animals; that multiple interactions may occur at once; the diverse social activities that may surround human–animal interactions; the distributed form of interactions between multiple participants; and the performative nature of some human–animal encounters.

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1. Introduction

Encounters between animals and humans are central to the objectives and practices of contemporary zoo experiences. Around the world, zoos are making increasing use of digital technologies to make those encounters more engaging and educational, while ensuring animal well-being. These take the form of digital media displays, information kiosks, and interactive signs, for example. In this paper we present a case study of a particular zoo in which we seek to understand how digital technologies are being deployed, and the significance of these developments for the field of Animal–Computer Interaction (ACI).

An important issue in ACI is how to conceptualise the

interactions between humans and animals and technology, and it is this question that we aim to address through studying the use of interactive systems at the zoo. Another significant aim of ACI research is to understand how technology is intervening in interactions and relationships between animals and humans (Mancini, 2011). In ACI work looking at technology to support human–animal interactions, the *interaction* under investigation generally involves a single human and a single animal. For example, ACI interventions have explored how technology can be used by animal–human pairs for shared play (e.g. Cheok, 2010; Noz and An, 2011), for remote communication and awareness (e.g. Lee et al., 2006; Mankoff et al., 2005; Resner, 2001), and for work (e.g. Mancini et al., 2015; Zeagler et al., 2014). Theoretical approaches to the design of such systems has therefore focused primarily on the challenge of designing interfaces and experiences which are appropriate to an individual animal and an individual human user.

Animal–human encounters at the zoo are seldom simple one-

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to-one affairs. Rather, they typically involve multiple parties, including social groups of visitors, zoo keepers and other staff. In this way, zoos provide a significant site to examine more complex forms of interaction. In recent work, [Weilenmann and Juhlin \(2011\)](#) argue for the importance of looking beyond the interactions between pairings of a single human and a single animal (human–animal dyads), to understand the broader social context in which animal–human–computer interactions occur. In studying the use of GPS technology in hunting with dogs, they demonstrate how technology use is shaped by, and plays a role in, the social organisation of the hunt. This work points to the fact that human–animal interactions often involve more than one human and one animal, and often occur in social contexts, or as part of broader social activities. Accordingly, our aim in this study is to explore in greater depth human–animal–computer interactions as part of diverse assemblies of animals and humans, and in the context of social settings.

Previous studies of visitor behaviour point to the important social and cultural dimensions of the zoo visit ([Hallman and Benbow, 2007](#); [O'Hara et al., 2007](#); [Sickler and Fraser, 2009](#)) and the influence of social circumstances on visitors' experience of the animal encounter (e.g. [Falk, 2006](#); [Kirchgessner and Sewall, 2015](#)). Further, studies of zoo animals highlight the fact that zoo animals have short-lived interactions with large numbers of visitors each day, but that these may have long-lasting, cumulative effects on the animal's generalised attitude towards humans ([Hosey, 2008](#)). In such studies, interactions are considered to include unobtrusive behaviours such as fixing gaze or making sounds ([Cook and Hosey, 1995](#)). Accordingly, at the outset of our study we adopt a broad notion of an encounter between animals and humans, which may consist of active or relatively passive behaviours.

The aim of our study is to investigate how specific choices in designing new digital technologies shape important aspects of the human–animal encounter. We examine not only the direct impacts of technology on face-to-face encounters, but also the broader interplay between technology and the diverse animal-human interactions and relationships that occur at the zoo. Organising our study as an examination of interactive systems and their impacts, we explore the significance of the various motivations of diverse stakeholders that underpin the design and use of these technologies. This entails exploring how a zoo uses technology to support its overlapping objectives, and exploring the discrepancies between design intentions and practiced reality, in terms of the consequences for animal-human interactions and relationships.

The modern zoo has a number of objectives including the conservation of threatened species and habitats, conservation education, animal welfare, research and visitor entertainment ([Fernandez et al., 2009](#); [Reade and Waran, 1996](#)). Offering the public opportunities for animal encounters underpins conservation campaigns and community education activities ([Clayton et al., 2009](#)). It is broadly accepted that opportunities to view animals in close proximity and exhibiting natural behaviour can result in a positive perception of animals and may influence the visitor's attitude towards conservation and environmental concerns ([Falk et al., 2007](#)), although these claims have not gone uncontested ([Marino et al., 2010](#)). The various objectives of the zoo can come into conflict with each other. For example, the zoo's objectives of attracting visitors and providing unobstructed views of animals at close quarters can conflict with the important aim of ensuring animal welfare. It has been found that visitor presence can cause stress amongst some species of primates (for example [Hosey, 2000](#); [Sherwen et al., 2015](#)).

To support the encounter with animals as a foundation for building interest in conservation ([Falk et al., 2007](#)) the modern zoo aims to create naturalistic, immersive environments which evoke specific habitats and provide a frame for conservation narratives

([Coe, 1985](#); [Finlay et al., 1988](#)). Naturalistic enclosures stimulate species' natural behaviour and cognitive engagement through forms of enrichment designed to appear like part of the animal's natural habitat ([Carter et al., 2015](#)). The provision of enrichment for zoo animals is not limited to the design of the enclosure; providing varied physical and cognitive stimulation is important in promoting animals' wellbeing and reducing stereotypic (maladaptive) behaviours ([Mellen and Sevenich MacPhee, 2001](#)). However, preparing enrichment activities is time intensive and resourcing constraints often place limits on keepers' capacity to meet animals' needs in this regard ([Hoy et al., 2010](#)). Keepers of intelligent species such as primates are faced with the challenge of creating enrichment activities which present sufficient novelty and challenge to continually engage animals' problem-solving abilities ([Brent and Eichberg, 1991](#)).

An important strategy in zoo's educational and conservation work is *interpretation*, in the form of presentations and media such as signs, photo boards and videos which convey factual information, campaign messages and affective material such as narratives. Modern zoo interpretation aims to complement the design of enclosures, support the visitor in making sense of what they see, and draw connections between the animals and conservation issues ([Andersen, 1991](#); [Weiler and Smith, 2009](#)). However, for visitors, opportunities for entertainment and recreation may be more important than the educational and conservation functions of the zoo. Zoos make continual efforts to appeal to diverse visitor interests by providing novel and fun experiences which enhance the animal encounter, rather than competing with it. Interactive systems are seen as providing basis for delivering visitor information, conservation messaging and student education in ways that are engaging and responsive to the needs of diverse visitor groups. Use of tablet computers by primates is seen as an opportunity for varied animal enrichment and also for engaging public interest, as evidenced by zoos' adoption of the *Apps for Apes* program ([Smith, 2011](#)).

The zoo thus provides an important site for research into animal–human–computer interaction. There are potentially significant roles for technology in enhancing animals' well-being, enriching their lives, and fostering positive human–animal relationships; objectives which align with goals proposed for ACI ([Mancini, 2011](#)). Furthermore, this is a site in which technology is already being deployed in the context of human–animal encounters. Studying this setting promises to provide new understandings of animal-human–computer interaction in a context which contrasts with the pairings of humans and companion animals or working animals, which provide the focus of much ACI work.

The perspectives and approaches offered by ACI have not yet been broadly applied to the zoo as a site of technology use. In this paper we seek to address this gap by examining how technology is impacting on human–animal encounters in the zoo, through a study of Melbourne Zoo as a typical case of an urban zoo that is actively deploying its own digital innovations. Our work contributes new understandings of the use of technology in this complex organisational and social setting, and the ways in which digital systems are intervening in encounters between humans and animals at the zoo.

As a site populated by people with diverse motivations and roles, and numerous groups of animals, the zoo provides opportunities to examine the social dimensions of human–animal–computer interaction, and technology use in the context of complex assemblies of humans and animals. This allows us to develop deeper understandings which may enable ACI researchers to “account for complex interactions” beyond the human–animal dyad, as called for by [Weilenmann and Juhlin \(2011\)](#).

2. Related literature

2.1. Animal–computer interaction

In recent years, the scope and methods of human–computer interaction have been extended to examine the design of interactive systems for animals. In a manifesto for animal–computer interaction (ACI) research, Mancini proposes three central aims for this emerging field: to enhance animals' quality of life and longevity; support animals in performing the roles assigned to them by humans (while optimising the impacts of such roles on the animals themselves); and support human–animal relationships. Of particular relevance to the context of the zoo, Mancini outlines an ethical basis for ACI research, placing central importance on animal welfare, animal-centred design, and, working towards positive outcomes for non-human individuals and species (Mancini, 2011).

2.1.1. Supporting human–animal dyads

Much ACI work explores the potential of technology to support greater understanding and positive interactions between animals and humans. The majority of this work has taken place in the context of human–animal dyads. For example, a number of research projects have investigated technology-mediated play between companion animals and their owners (Cheok, 2010; Hauser et al., 2014; Noz and An, 2011; Trindade et al., 2015; Westerlaken, 2014; Young et al., 2007). Other researchers have trialled systems which aim to provide pet owners with remote awareness of their animal's behaviour and affective state, and allow them to interact at a distance (Lee et al., 2006; Resner, 2001). Continuing partnerships between working animals and their handlers provide a significant opportunity for ACI researchers to investigate and augment mutual understandings between humans and non-humans, within the context of a specific task (Mancini et al., 2015; Robinson et al., 2014a; Zeagler et al., 2014).

The focus of this research on interactions between animals and humans in the context of one-on-one, enduring relationships has shaped approaches to identifying ACI interaction mechanisms and design methods. For example, handlers' extensive knowledge of individual animals' behaviours, and mutual interspecies understandings constructed through multiple interactions and historical knowledge of the individual, are brought to bear in approaches such as multispecies ethnography (Mancini et al., 2012) and play-based approaches to ACI design (Jørgensen and Wirman, 2016; McGrath, 2009; Westerlaken and Gualeni, 2013).

2.1.2. Social dimensions of animal–computer interaction

Studies of technology-mediated interaction between these human–animal pairings have generally centred on settings such as the home (Mankoff et al., 2005; Robinson et al., 2014b) or laboratory (Mancini et al., 2015; Trindade et al., 2015; Zeagler et al., 2014), and have thereby given little attention to broader social considerations and factors that intersect with animal–human interactions. While it is broadly acknowledged that the social context shape our expectations of animals and the work that they do (Mancini et al., 2012), to date ACI has lacks a general framework for understanding or responding to such social and cultural factors.

Important insights into the social dimensions of ACI are provided by Weilenman and Juhlin (2011). In their study of the use of GPS by hunters to track their dogs' movements, they identify how the broader context of the hunt and other sensory cues shape hunters' understandings of their dogs behaviours, as mediated through the technology. They also indicate how the technology use plays a role in shaping the interactions between hunters, thus influencing the social context and the way that the hunt unfolds. This work points to the importance of looking beyond dyadic

relationships, to attend to the broader social context and surrounding activities in which human–animal interactions take place, and the need to consider how these may intersect with between technology-mediated interactions.

2.1.3. Interspecies awareness and environmentalism

Several researchers have considered how ACI research can contribute to existing HCI work to support environmental awareness and sustainable living. Mancini and colleagues propose a role for ACI in sustainable food production, identifying the opportunity for approaches and interaction mechanisms which allow farm animals to participate in the design of more environmentally-sound agricultural practices (Mancini, 2013). Recent work has further investigated this proposition, examining how the familiar design tool of personas might be adapted to represent animals as stakeholders to farming processes (Frawley and Dyson, 2014). These ideas are extended in work which explores co-design with trees, water or bees (Bastian, 2013), and in the proposal of a Human–Computer–Biosphere Interaction framework for digital interaction with environmental systems (Kobayashi et al., 2013). As these examples indicate, there is emerging interest in the potential role of ACI in contributing to biodiversity awareness and the consequences of human behaviour for other species.

Zoos explicitly seek to motivate conservation awareness and action through experiences and spaces which bring animals and humans together. For the sector's global peak body, the World Association of Zoos and Aquariums, conservation is central to the work of zoo organisations (World Association of Zoos and Aquariums, 2015). This context thus provides a fertile site in which to further explore the potential role of ACI in fostering sustainable living and environmentalism.

2.2. Interactive technology at the zoo

Zoo-based research has established the value of engaging animal experiences as part of zoos' strategies for community conservation and education. Opportunities to see animals in a naturalistic environment at close range, and observe them engaging in natural behaviour can result in positive visitor attitudes towards the species, and encourage interest in related conservation issues (Ballantyne et al., 2007; Clayton et al., 2009). A “profound experience”, or moment of personal connection with wildlife can engender significant positive attitudes towards a species and its conservation (Weiler and Ham, 2011). Accordingly, zoos seek to design exhibits which allow visitors a good view of animals at close proximity, and which create an impression of the animal's natural environment (Fernandez et al., 2009; Luebke and Matiassek, 2013). In addition to the exhibits themselves, zoos provide a range of interpretive materials and experiences which aim to reveal to visitors the significance of the animals on exhibit (Moscardo et al., 2004). Studies conducted in a number of zoos indicate that presentations and talks conducted with live animals can have significant impacts on the audience's attitude to conservation issues (Clayton et al., 2009).

Research in Human–Computer Interaction (HCI) reflects interest in zoo-based interactive technologies for interpretations, education and entertainment. This prior work investigates, for example, the social dimensions of mobile-phone based acquisition of knowledge about animals (O'Hara et al., 2007), and docents' use of information to support interactive, educational games (Jimenez Pazmino et al., 2013). Technology-based visitor education offers the potential for effective delivery of information (Perdue et al., 2012b), and creating learning experiences which are attractive to children (Ohashi et al., 2008; Suzuki et al., 2009). However, a central challenge consists of designing and implementing systems so that they strengthen, rather than detract from, the visitor's

visual connection with the animals on exhibit (Kelling and Kelling, 2014). Accordingly, there is strong interest in smartphone-based augmented reality systems as a means for visitors to access information about the animals they view (Karlsson et al., 2010; Kelling and Kelling, 2014; Perry et al., 2008).

2.3. Interactive technology for zoo animals

Several researchers have investigated digital interactive technologies for non-domesticated species kept in zoos and other captive settings. In line with ACI's proposed aim of supporting animals' welfare and quality of life (Mancini, 2011), a number of studies have investigated digital interactive technologies as a form of environmental enrichment (Boostrom, 2013; French and Mancini, 2014; Wirman, 2013a). In work conducted at Edinburgh Zoo it was found that a system combining touchscreen computers and cameras could be used to effectively monitor the welfare of chimpanzees (Herrelko, 2011). Clay and colleagues conducted a small survey of technology use in North American zoos, concluding that zoo personnel are enthusiastic about the potential benefits of digital technologies for primate enrichment and care (Clay et al., 2011).

Technology for zoo animals can also be understood as a means of supporting the animal's role in the visitor education and conservation campaign work of the zoo. There are significant opportunities for ACI to contribute to the welfare of animals in zoos through providing enrichment, environmental control, and opportunities for social or human interaction (Rault et al., 2015). This corresponds to ACI's goal of enabling animals to fulfil their human-assigned functions in ways which minimise negative welfare impacts and maximise the benefits to the animal (Mancini, 2011). For example, footage recorded by chimpanzees at Edinburgh Zoo provided material for a publicly broadcast television documentary, and demonstrated the potential for such interventions to shape the public understandings of animal wellbeing and zoo-based research (Herrelko, 2011). Introducing digital technology in this context raises some concerns regarding encouraging 'unnatural' animal behaviours and the potential disruption to the effect of naturalistic enclosure settings and 'landscape immersion' (Finlay et al., 1988). However, a study of a touchscreen device in an orang-utan enclosure at Zoo Atlanta concluded that animals' use of technology does not diminish the overall visitor experience, and found that visitors held broadly positive attitudes towards technology for orang-utan enrichment and for visitor education (Perdue et al., 2012a).

There are some indications that in this setting also, technology can "foster the relationship between humans and animals" (Mancini, 2011). For example, Wirman proposes that touchscreen technology for orang-utan enrichment can provide opportunities for playful connections between humans and animals (Wirman, 2013a).

In this study, we explore how the use of technology at the zoo is impacting on the human–animal encounter. Zoos are recognising the potential role of interactive technology in addressing their challenges of providing continuously novel animal enrichment, and offering visitor experiences which are engaging, educational and which extend (rather than competing with) the experience of viewing the animal. To examine this, we draw on ACI approaches, which we believe offer important tools for investigating the impacts of technology on the social and organisational practices conducted at the zoo, and in exploring approaches to design and evaluation of technology for humans and non-humans in this context.

We contend that zoos' focus on human–animal encounters and animal wellbeing makes this a site of considerable interest to ACI researchers. To engage in this space, ACI will need to develop

approaches appropriate to working with captive, non-domesticated species in the context of animals' short-lived encounters with multiple, unfamiliar visitors as well as familiar keepers. In this paper, by interrogating the use of technology at the zoo and its impact on human–animal encounters we seek to provide a basis for future design and research in the zoo, and offer insights relevant to ACI research for other contexts.

3. Methodology

3.1. Research design

To explore technology use in a rich, social context, we examine the ways in which digital technology is already being used by diverse assemblies of humans and animals as part of the zoo's core work, and investigate how this impacts on animals, visitors and the zoo organisation. To obtain rich, in-depth insights into the intersections of technologies in use, practices of zoo personnel and visitors, and organisational priorities, we elected to conduct a case study investigation into technology in use at a specific zoo. Case study research provides a mechanism to conduct "an empirical enquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2009, p. 18), and is a method commonly adopted to explore information systems in an organisational setting (Orlikowski and Baroudi, 1991). This thus provides an appropriate method for making a holistic study of the interactions between the relationships and processes that exist in the context of the zoo, and the use of interactive systems.

With the aim of delivering a rich, in depth understanding of how technology is currently being used in this context, we conduct a descriptive study (Oates, 2006) which investigates the phenomenon in its "natural setting"; that is, contemporary use of technology in the zoo context, with minimal intervention from researchers. Through this we consider the complex social, organisational and external factors that have shaped the systems and the way they are used. Focussing on a single zoo allowed us to give sufficient attention to the rich organisational context in which technologies are being designed and deployed.

3.2. Case selection and background

We elected to conduct the case study at Melbourne Zoo, a site which was chosen on two grounds. Firstly, it is typical of a general zoo for a large urban population. As a modern zoo, it aims to provide opportunities for live animal encounters with a focus on conservation, visitor education and engagement, and animal welfare. Secondly, and most importantly, in recent years it has been actively appropriating and configuring new digital technologies which support these core activities. This study was initiated at the outset of a broader collaboration between the research team and Zoos Victoria (the organisation which manages Melbourne Zoo and two other zoos in the region). One aim of this study is to inform continuing investigations into digital technology for animal enrichment and visitor engagement; however at the time of this study the research team had no involvement in the design, deployment or evaluation of zoo systems or processes. Although researchers had an existing relationship with Melbourne Zoo, consideration was given to well-established zoos in Australia where this research might be conducted, on the basis of prominence, organisational model, and visitor numbers. Five sites were identified as well-regarded, typical urban zoos; of these, three were found to be actively deploying and using digital technologies in support of core activities. Weighing these three alternatives, it

was determined that while they could all be suitable sites, Melbourne Zoo would allow for deeper investigation and greater access to personnel, due to our existing relationships.

The scope of our study includes digital systems (which we also refer to as 'interactive systems') deployed by the zoo as part of its organisational objectives. Through this, we examine the use of systems in the social context of the zoo visit, comprising divergent individual motivations (of visitors and personnel) and diverse assemblies of humans and animals. In the case of Melbourne Zoo, this includes systems used by animals and systems used solely by humans. Prior ACI research has examined human use of interactive systems which mediate interspecies interactions and understandings, including dog tracking technologies (Mancini et al., 2012; Paldanius et al., 2011; Weilenmann and Juhlin, 2011). We go beyond this, investigating also how human-only technologies used in proximity to animals setting impact on human–animal encounters, interactions and relationships.

In accordance with our aim of studying diverse perspectives on the use of technology in this rich social context, our case study examines five instances of digital technology deployed and used as part of distinct but overlapping organisational objectives. While the Zoo as a whole forms the case to be studied, these five systems comprise separate 'units of analysis' (Yin, 2009). Initial investigations at Melbourne Zoo identified seven interactive digital systems directly supporting core activities and objectives, as distinct from technologies for coordinative purposes, (such as ticketing, payroll and customer relationships). During a preliminary inspection it was found that these seven systems could readily be categorised according to their alignment with core organisational activities (Table 1).

The five systems selected for study, listed below, were chosen so as to ensure we studied at least one system representative of each core activity. In the Animal Interpretations category, we elected to study both the *Volunteer iPads* and *Digital Signs* so as to address an interpretations system used by visitors alone, and a system used by zoo personnel with visitors.

1. *Educator Screens*: iPads, Apple TVs and television screens used by educators with school groups.
2. *Volunteer iPads*: iPads used by volunteers to show photos and videos to waiting visitors.
3. *Digital Signs*: iPads installed near enclosures providing species labels and information.
4. *The Zoopermarket*: Custom supermarket-themed interactive installation.
5. *Apps for Apes*: iPads offered to orang-utans as an enrichment activity.

3.3. Data gathering

Following the case study approach, multiple sources of evidence were consulted, to allow cross-validation of evidence and to build a richer account. The primary aim in selecting multiple forms

of evidence was *data triangulation*: that the facts identified through the study should be supported by multiple sources of evidence (Yin, 2009). A secondary goal was to gain insight into a range of perspectives and issues related to the use of technology. As part of initial investigations at the Zoo, we identified three suitable forms of data which could be compared and used as part of this strategy of corroboration: interviews, documents and technical artifacts.

3.3.1. Interviews

Interviews were used to learn about the digital systems at the Zoo and staff perceptions of these and, more broadly, to inquire into motives and perspectives regarding the intersection between the objectives of the zoo and digital technologies. Zoo personnel responsible for the design, delivery and management of the five selected systems were invited to participate in interviews. The first of these employees were identified through the lead researcher's personal connections with the Zoo. From this, snowball sampling (Neuman, 2006, p. 223) was used: personnel participating in this study were asked to refer us to other personnel involved in the deployment and management of the selected systems. We continued to ask our growing network of Zoo contacts for referrals until no additional relevant personnel were suggested. Through this, we interviewed seven personnel in total (Table 2): members of the interpretations team [I1, I2] (responsible for information and installations that support visitor understanding), the education program [E] (responsible for presentations to school groups), the primates department [K], the volunteer program [V1, V2] and the information technology service [T].

Interview scripts were prepared by the research team and semi-structured interviews were conducted by the lead researcher. Participants received an overview of the study aims and provided written consent to take part in the research. Interviews lasted 30–70 min.

In addition to the above interviews, informal conversations with zoo personnel were used to validate researchers' understandings and perceptions, as recorded in field notes.

3.3.2. Technology inspection

Examining physical artefacts is a recognised source of evidence for a case study (Yin, 2009). In this case, we aimed to gain familiarity with the digital systems and content, to be able to contextualise observations of the systems in use, but also corroborate the information provided by interviewees about how systems worked and how they would be used. A detailed inspection of each of the five systems was conducted, including the digital content. The lead researcher reviewed visitor-facing technology during quiet times when no visitors were present. Zoo personnel were asked to provide a demonstration of systems used by staff, following which the lead researcher conducted further inspection of

Table 1

The seven digital systems aligned to zoo objectives. Five systems (indicated by *) were selected for analysis.

Zoo activity	Digital systems
Animal interpretations	<i>Volunteer iPads*</i> , <i>Digital Signs*</i> .
School programmes	<i>Educator Screens*</i>
Conservation action	<i>Zoopermarket*</i> ; <i>Wipe for Wildlife Pledge Board</i> ; <i>Join the Pack Counter</i>
Animal enrichment	<i>Apps for Apes*</i>

Table 2

Zoo personnel interviewed.

Code	Department	Role
I1	Interpretations	Design, deployment and ongoing operations of <i>Zoopermarket</i> and <i>Digital Signs</i> .
I2	Interpretations	Deployment and ongoing operations of <i>Zoopermarket</i> and <i>Digital Signs</i> .
E	Education	Design, deployment and ongoing operations of <i>Educator Screens</i>
K	Primate Keeping	Use of <i>Apps for Apes</i> with orang-utans
V1	Volunteering	Design, deployment and ongoing operations of <i>Volunteer iPads</i>
V2	Volunteering	Use of <i>Volunteer iPads</i>
T	Information Technology	Management of information technology infrastructure and services

content and features. Salient aspects of the systems were noted, screenshots taken and screen-flows recorded, where appropriate.

3.3.3. Observations

Direct observations provide an important method of case study data collection which can reveal new understandings of a context, actual behaviours (as distinct from reported behaviours) and relevant issues (Yin, 2009). We observed use of the digital systems in the field and took field notes recording how intended users interacted with the systems, visitor group dynamics around the system, and the extent to which visitors engaged with, or ignored the system. Familiarity with system design and content (obtained through the technology inspection) allowed researchers to record which features were used and in what ways, and identify when anticipated patterns of use were not followed.

Three observations were conducted of each of the *Zoo-permarket*, *Digital Signs* and *Educator Screens*. Visitors' use of the *Zoo-permarket* and *Digital Signs* was observed in three fifteen minute sessions conducted on a weekday morning, a weekend morning and a weekend afternoon; these were scheduled to provide coverage of peak visiting times (weekends) and quieter times (weekdays). Three educational sessions (including use of the *Educator Screens*) were observed on a single weekday. These sessions were led by two educators (E1 and E2), and were conducted in two different settings with school groups of different ages. These included an introductory presentation and a closing presentation conducted with large groups of students in a public area before and after their tour of the Zoo, and an educator-led animal encounter in a dedicated education space with a small class of early-years students. *Apps for Apes* was observed in a single observation session lasting approximately 20 minutes; during this session the iPad was held by one of the primate keepers [K2] and used by four of the six orang-utans at the Zoo (keepers have previously found that the remaining two orang-utans, a dominant male and an infant female, are uninterested in the iPad). The *Volunteer iPads* were not in general use at the time of this study so use of this system was not observed.

3.3.4. Documents

To obtain a broader perspective on the zoo's goals and activities, the organisation's most recent public-facing publications were identified and consulted. The focus of this document review was to gain a deeper understanding of the organisational context, the Zoo's strategy and operations, and the role of human–animal encounters as part of its core activities. This background information also provided insights into organisational perspectives relevant to the deployment and use of technology. The following documents were reviewed:

- Zoos Victoria Strategic Plan (2009–2029) (Zoos Victoria, 2009).
- Zoos Victoria Corporate Plan (2014–19) (Zoos Victoria, 2014a).
- Zoos Victoria Annual Report (2013–14) (Zoos Victoria, 2014b).

3.4. Data analysis

To facilitate analysis, interviews were transcribed. Researcher field notes were collated, along with materials and notes from technology inspections. These sources of evidence, along with the Zoo documentation, were categorised according to unit of analysis (a specific interactive system, or the zoo as an organisation). We then conducted a thematic analysis, with the aim of understanding how technology is impacting on human–animal encounters, with respect to the aims of the zoo and the interests of visitors. Our analysis was guided by existing knowledge regarding the motivations of zoo visitors, the experience of wildlife encounters, and the factors that impact on the educational and conservation aims

of the zoo.

Studies of the zoo visit have identified a number of factors that impact on visitor outcomes pertaining to zoos' objectives. In this study we therefore focus on factors which have been found to influence visitors' sense of connection to the animal and their perceptions of animals and zoos

With the aim of identifying sensitising concepts for the investigation, we reviewed existing literature on the animal encounter at the zoo, and wildlife encounters, with a focus on those qualities which have been related to the visitor experience, or to zoos' educational and conservation goals. In an influential exploration of how zoo design influences the visitor experience, Coe (1985) identifies the importance of the visitor's distance from the animal, the viewing position relative to the animal, the sense of "landscape immersion", and the creation of memorable experiences through qualities such as anticipation, absence of distractions, novelty, fulfilment of expectations, the engagement of emotions, and opportunities to revisit encounters. It is generally understood that a visitor's *sense of connection* to an animal is associated with conservation learning (Ballantyne et al., 2011; Clayton et al., 2009). Other zoo-based literature has identified the positive visitor impact of the visibility and proximity of the animal (Tofield et al., 2003) and animals' activity levels (Anderson et al., 2003). This is also relevant to studies which indicate that seeing animals in naturalistic exhibits that encourage natural behaviours has positive impacts on visitors' interest and their overall experience (Finlay et al., 1988; Rhoads and Goldsworthy, 1979; Tofield et al., 2003) and seem to result in more positive perceptions of the animals and thus greater empathy for them (Reade and Waran, 1996).

Studies of wildlife tourism also point to specific factors which shape the impact of encounters with animals. For example, Ballantyne and colleagues find that emotionally-charged experiences and, in particular, visitors' sense of "wonder, awe, excitement and privilege" are associated with powerful, lasting memories of the encounter (Ballantyne et al., 2011). They also point to the importance of visitors reflecting on an encounter and making personal connections to the wildlife they have seen, a factor also important to learning in the zoo context (Yocco et al., 2011). Reynolds and Braithwaite (2001) propose that in addition to similar affective qualities of uniqueness, intensity and authenticity, the duration of the encounter, and perceptions of the species will impact on the visitor's experience.

We reviewed the literature cited above to identify qualities of the visitor experience mentioned in these works. A list of dimensions of the visitor experience was created and through affinity diagramming the terms were categorised to identify overarching concepts. From this, we selected those dimensions which relate to the human–animal encounter. For example, we excluded factors that relate to those communication or educational strategies which can be isolated from the animal encounter. We also excluded factors related to animal species (such as species popularity and conservation status). Through this synthesis, we identified the following qualities of the visitor experience of the human–animal encounter.

- *Proximity*: minimising distance from the animal.
- *Visibility*: getting a good view of the animal and its active behaviours.
- *Sense of uniqueness*: perceived unique interaction or special connection with the animal.
- *Sense of personal connection*: sense of similarity, emotional connection or responsibility.
- *Sense of wonderment*: admiration of animal's attributes or abilities.
- *Sense of immersion*: sense of being immersed in the animal's

environment.

- *Sense of animals' wellbeing*: perception that animal is happy, healthy and well cared for.

These sensitising concepts provided a frame for analysing how interactive systems are impacting on the human–animal encounter by impacting on specific dimensions of the experience. Each form of data was first analysed independently. Key themes and outcomes of this analysis were thematically organised, and sources of evidence were then compared to seek corroborating evidence, and points of divergence. Through this process we developed a rich understanding of the five interactive systems, considering not only how they support the work of the zoo, but also issues that may indicate tensions between existing practices and the deployment of technology.

4. Findings

In this section we first present findings relevant to the context of the site studied, and the general aims and approaches of Melbourne Zoo with respect to technology deployment and use. From this, we turn our attention to each of the five interactive systems in turn, identifying how they intersect with the organisation's overall aims and objectives, noting barriers to successful deployment and adoption, and outlining the effectiveness of the system in achieving its goals, and perceptions of personnel and visitors.

4.1. Melbourne Zoo

Melbourne Zoo ("the Zoo") is one of three non-profit zoological parks in Victoria, Australia operated by Zoos Victoria, and overseen by a statutory authority of the State of Victoria. Government funding accounts for slightly more than a quarter of Zoo Victoria's income, with the remainder generated through visitor revenues and commercial activities. The zoo has been operating since 1862 and has a collection of over 250 animal species (at 2014). Located 4km north of Melbourne city centre and easily reached by public transport, the Zoo is a popular attraction, receiving over 1.2 million visitors during the 2013–14 financial year, with an average visit time of 3–4 h. Families with young children form a significant component of the visitor base particularly since the Victorian Government's introduction in 2011 of free entry for children on weekends and during holidays. Zoos Victoria also attracts repeat visitors through a members program which at 2014 numbers 160,000 subscribers. Melbourne Zoo personnel comprise approximately 150 staff (full-time equivalent), and 300 volunteers who provide a presence at selected locations around the zoo to answer questions and support specific educational and campaign messages.

4.1.1. Zoo aims and the animal encounter

Zoos Victoria has a strong focus on conservation, as reflected in the vision "to be the world's leading zoo-based conservation organisation" (Zoos Victoria, 2014b). The organisation's goals are further shaped by its membership of the World Association of Zoos and Aquariums (WAZA) and the Association of Zoos and Aquariums (AZA), and by the responsibilities of the governing statutory body, which relate to promoting public enjoyment and awareness of the animal collections and parks; wildlife conservation; zoological research; and public consultancy on zoological matters. Field-based conservation projects focused on management of threatened species, habitat protection and captive holding programmes are conducted locally and with international partners.

The organisation also places considerable emphasis on working

with the public to encourage commitment to conservation action and associated behaviour change at a community level. This goal is encapsulated in the organisation's framework of Connect, Understand, Act, which provides a platform for design of exhibits, experiences and presentations. Within this frame, the visit to the zoo is considered an opportunity for animal-based experiences which aim to create a connection with the animal, enable visitors to understand the plight of wildlife and inspire conservation action. As part of achieving this while ensuring safety of animals and visitors, the Zoo aims to create environments where the visitor feels that they are closer to the animal than they actually are, and experience up-close encounters which generate the sense of a one-on-one connection. In the design of exhibits, the effect of this has been to minimise use of fences and bars in favour of moats, palings and glass walls; for example, large portions of the lion enclosure are surrounded by glass walls, as well as secure mesh which allows visitors to touch the lion's mane and feel its breath when it approaches. These aims are also evident in presentations conducted regularly at many animal exhibits; for example an orang-utan will, on cue, hold their palm to the glass, while a visitor places their hand up against it on the other side of the glass.

Zoos Victoria places considerable importance on matters of animal welfare and has recently appointed a dedicated welfare specialist, becoming one of only a handful of zoos organisations worldwide to have such a position on staff. Welfare encompasses not only ethical care and nutrition, but also ensures all mammals receive varied enrichment and, where appropriate, training as a basis for cognitive stimulation and to facilitate care activities. In line with a worldwide trend in management of elephants and other mammals, the Zoo has introduced 'protected contact' in which keepers no longer enter enclosures with the animals; this has consequences for the selection and use of certain enrichment devices and activities.

4.1.2. Interactive systems at Melbourne Zoo

Technology has been deployed at the zoo either as part of a programmed exhibit construction or expansion (as in the case of the *Zoopermarket* and the *Digital Signs*) or opportunistically, as business units have identified ways in which technology can address a specific operational need (*Educator Screens*, *Volunteer iPads*, *Apps for Apes*). As a non-profit organisation which receives a considerable proportion of its funding in the form of project allocations, there can be issues in assuring on-going budget for continued support, maintenance, and updating of content and hardware.

The presence of innovative technology is seen as something that can give the Zoo a competitive edge over other attractions, and draw attention to the organisation as a world-leading zoo. Thus, the use of technology in this context is considered to impact on a very broad public audience, their perception of the zoo and their attitude to animals. The use of video and audio media is seen as a powerful tool which can connect the visitor to the "authentic object" [I1] and play a role in telling a "powerful story" [E] to inspire commitment to protecting wildlife. All functions of the zoo are constrained by limited personnel and resources, and so are interested in using digital technology to extend their capacity to create one-on-one connections between visitors and animals, strengthen visitors' understanding of wildlife threats, inspire conservation action, promote a specific educational lens to students, and provide new forms of enrichment. These motivations underpin the five systems described below.

On the other hand, zoo personnel generally consider that innovative technologies *per se* will not be a primary motivator for a visit to the zoo; in contrast, destinations such as museums are seen as attractions which can benefit directly from public fascination with novel interactive systems. Furthermore, the zoo

considers the encounter with animals to be central to the visit experience that they aim to create; this is the focal point of zoo design and landscaping, presentations, and other interpretive materials. There is a concern that interactive systems which are overly conspicuous or engrossing may distract, or reduce the impact of viewing the animals. We explore how these tensions are managed in the design and use of the five interactive systems we studied.

4.2. System 1: educator screens

Melbourne Zoo's educators deliver to school groups programmed learning experiences consistent with the wildlife and conservation education goals of the organisation. This system aims to support meaningful encounters between animals and large groups of students. It also allows educators to draw on their dyadic interactions with animals and share this experience with a large audience. Educators use handheld iPads to access resources and visuals, and can connect these via wireless network to AppleTV devices installed in the indoor spaces where they work. AppleTVs are used to mirror the iPad content to televisions and large-format displays, providing even large school groups with good visibility of the digital materials (Figs. 1 and 2). In the course of learning experiences sessions, educators display presentations preloaded on the iPads, and also have access to a library of photos and videos related to topics covered.

4.2.1. Aims and objectives

Educators aim to shape students' time at the zoo as a learning experience through sessions conducted at the beginning, middle and end of their visit. Prior to deployment of the *Educator Screens* system, educators used laminated photo cards; iPads were introduced as a way of providing educators with easy access to a large digital library of photos and media, increasing educators' ability to respond to unanticipated questions from students. Within Zoos Victoria as a whole, and amongst educators in particular, use of video and audio recordings of animals within presentations is seen as a powerful technique, and one that can play a significant role in building a commitment to protecting wildlife conservation. Educators are keen to investigate the potential of interactive technologies to maintain students' focus on the educational frame during their visit, draw student's attention to lesser-known species, and provide engaging learning experiences without the need for an educator to be present. The overarching



Fig. 2. *Educator Screens* – Television connected to AppleTV, alongside animal enclosures in a dedicated learning space.

aim is to enable educators to shape the experience of large groups of students as they encounter animals, even though the educator may be absent when the encounter takes place.

Introductory education sessions conducted at the beginning of a school visit are designed to motivate and scaffold students' exploration of animal behaviour and attention to conservation issues. In these sessions, digital presentations are used to elicit students' prior knowledge and to share animal stories relevant to the zoo's focus on biodiversity and protection of threatened species. In concluding sessions, students are asked to reflect on their visit and respond to topics of enquiry posed earlier. To support this, photos of animals are used to prompt students to recall their experiences and encounters with animals. In other sessions, educators bring animals out of their enclosures for students to touch or get close to; as part of this the educator might draw attention to specific features of the animal. These features would provide a focus for subsequent discussion, in which educators might make use of photos and videos on the iPad.

In addition to displaying stored media, the system is used by some educators to provide a live video feed of animal demonstrations conducted with a school group. To enable groups of students to get a close look at these features, some educators video the animal at close quarters with the iPad or mobile device and display the output to a large screen display via the AppleTV.

4.2.2. Challenges and barriers to use

Training and assistance has been necessary to achieve good uptake of the system by educators, as the team's confidence and experience with technology varies considerably. A pivotal requirement is that educators should be able to easily set up and start using the system when they enter a space; educators are not disposed to manage technical delays or glitches while in front of a group of students and their teachers.

"It has to just be so easy, because any problems or any sort of anomalies to it, people start just going, 'I've got 30 kids here, I've got 20 minutes to get something across to them, if there's any problem... I'm not going to bother.'" [E]

In observing educational sessions, we noted that in some spaces charismatic animals such as elephants and seals were visible, drawing students' attention away from the educator and from the digital presentation; this created an additional challenge of student engagement for educators working in these spaces.

In observing educators' use of the system to provide a live video feed of an animal demonstration, we found that this requires

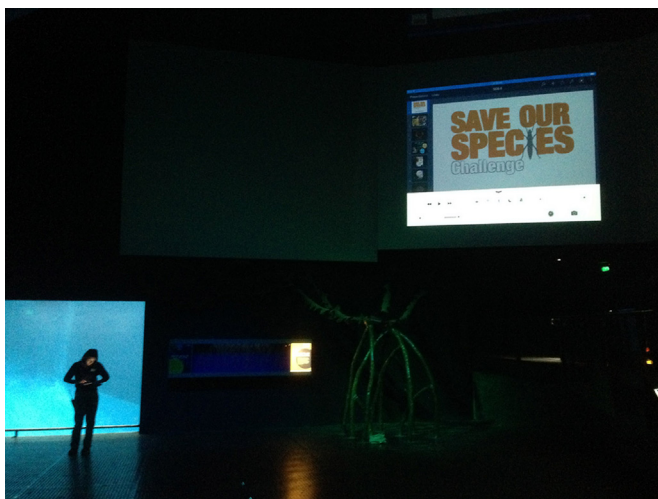


Fig. 1. *Educator Screens* – Educator preparing to use iPad to deliver a presentation to school children on large format display in *The Deep*, an immersive 'submarine' visitor space.

concurrent handling of the mobile device and the animal. Connecting the mobile device to the screen demands a few seconds' focused attention, but the mobile device might be put down rapidly if both hands are needed to handle the animal or other objects. In addition, educators continue to deliver lesson material or answer student questions, and pay attention to the behaviour of the group to ensure safety of visitors and the animal. As a result of the challenges of managing so many elements of the learning experience concurrently, it is reported that many educators avoid this use of the system altogether while others may choose to appoint students to handle the mobile device – a task which young people do not always accomplish effectively. The educator we observed chose to use their iPhone, rather than an iPad, to provide the video feed; we surmise that this is due to the fact that the phone can more easily be managed with one hand than the tablet computer.

4.2.3. System outcomes and perceptions

Following a period of introduction and training, the *Educator Screens* system is now used as standard by educators, and is considered to be relatively reliable and easy to use. Use of large screen displays enables educators to show media to a large group at concurrently. An early evaluation of iPad use by Melbourne Zoo educators indicated that teachers believed their students found iPad content more engaging than printed photographs, increasing the effectiveness of animal encounters (Coleman, 2012). It is thought to be that this might have been partly due to the relative novelty of the iPad at the time the study was conducted.

However, television screens are also found to be very effective in capturing students' attention.

"If you say to the kids, 'Guys, come and look at the TV,' that's a great way to get the kids attention [clicking fingers], like almost as good as getting an animal out itself" [E].

On the other hand, it is important to educators that technology should not intervene in students' observation of an animal if it offers no benefit. For example, educators described an iPad app which allowed students to view an animal as if through binoculars, but commented: "all it was really doing was making a kid look at an iPad and not the real deal" [Educator].

Our observation of an early years school group indicated that students were able to attend to both the presence of the animal in front of them and the live video feed on the television screen, obtaining a live, close-up experience of the animal only possible through combining both modes of viewing. Students were also excited to see a live feed from the back room as the educator returned a snake to its enclosure, watching eagerly as it gradually buried itself.

The system allows some flexibility to the interests of individual educators. Educators can contribute content to the library loaded on to the iPads, and can select the images they find most useful, tailoring the use of resources to their own teaching preferences. Depending on their level of confidence with the system, educators can choose to augment students' animal experiences.

"There's lots of value-adds that you can do on the iPad that people have started [...] at Wild Sea, we can flick it to Apple TV, we can flick it back to the media loop, or we can flick it to the video camera that's happening at the top, so we can see the animals in the top pool". [E]

The *Educator Screens* have also allowed some innovation and standardisation in the way that learning experiences, enabling delivery of prepared presentations aligned with each of the educational programmes.

4.3. System 2: volunteer iPads

The Zoo's volunteers have access to iPads which can be used to show photos and other media of animals to visitors. These were first used with visitors following the birth of a gorilla in April 2015, an event which was anticipated to attract large numbers of visitors and result in long queues at the gorilla exhibit. From the first public viewing day, volunteers responsible for assisting with queue management were issued with iPads containing high quality photos and videos of the gorilla and its birth. Volunteers offered to show the photos to visitors waiting in the queue, and those groups unable to get a good view. This technique aims to replicate the experience of an individual, one-on-one encounter with the animal, to allow large numbers of visitors to share in a personal, 'unique' interaction (Fig. 3).

4.3.1. Aims and objectives

Volunteer iPads were introduced with the aim of improving the experience of visitors queuing to attend popular exhibits during busy periods. The birth of a high profile animal attracts large volumes of visitors. Crowding and associated issues of animals' visibility cause considerable pressure for the zoo and volunteers who help to manage queues during such events. Zoo personnel recognised that many visitors hoping to see the young gorilla would be prevented from doing so by the protective behaviour of gorilla mothers and the design of the enclosure, which allows gorillas freedom to remove themselves from visitors' view.

"I'm standing at the front of the queue knowing these people aren't going to see a gorilla baby. Because she's like this big [holds hands up], and Kimya [her mother] was holding her at her chest and half the time Kanzi [the baby] was asleep" [V1].

Using iPads to show visitors photographs and video of the baby gorilla and mother provided volunteers a mechanism to improve the visitor experience of waiting and reduce the disappointment of those who were unable to see the animals.

4.3.2. Challenges and barriers to use

Defining an ongoing process to transfer media to iPads has been a challenge for the volunteer programme, largely due to recent staff changes and resulting discontinuity. Consequently, only a limited number of images of the gorilla baby were transferred to the iPad, despite the availability of many high quality images and videos. Images of the baby shortly after birth were quickly thought out of date and uninteresting to visitors, but updated images were not made available on the iPads. Some volunteers sought to copy photos from their own devices on to the iPads but were unable to



Fig. 3. Volunteer iPad – sample photograph of baby gorilla with mother.

do so. These challenges meant that iPads were not used during the birth of a pygmy hippo which occurred at the time of our observations at the Zoo, and are currently little used with visitors.

4.3.3. System outcomes and perceptions

An event such as the gorilla birth is seen by the zoo as an opportunity for creating and strengthening connections between animals and visitors. Volunteers' use of iPads at this time successfully capitalised on this opportunity by responding to visitors' desire for a close encounter with the animal through offering high-quality, close-up images of gorilla baby and mother.

"[We had] some fantastic photos, so it meant those people were then seeing 6 or 7 photos from different perspectives" [V1].

This success was found to depend on having up-to-date and high-quality media. Viewing these intimate images with the volunteer can create for visitors the sense of an exclusive experience.

"People are happy to look at the animals, but they enjoy when there's something extra. They assume it's maybe [...] a special behind the scenes kind of thing" [V1].

The volunteers are interested in the potential of the iPads as a tool to strengthen and build on visitors' connections with animals and respond to their interests.

"So many mothers were interested in the [gorilla birth] process" [V1].

This is also seen as a means to provide repeat visitors with an enduring connection to animals they have an interest in, including those moved to other zoos. Interactions around media or specific information can also provide an opening to discuss conservation campaign messages with visitors.

"If they're already used to talking to you about animals you can start that [campaign related] conversation" [V1].

Showing media on the iPads is also seen as a potential mechanism to increase visibility and knowledge of less familiar species, in particular the twenty species selected for special protection by Zoos Victoria, not all of which are on display at Melbourne Zoo.

4.4. System 3: Digital Signs

iPads are used as *Digital Signs* at *DigestEd*, a recently constructed space primarily for scheduled school programmes but accessible to visitors at other times. The external wall of the space looks through to the Philippines Crocodile enclosure; three *Digital Signs* installed in the wall provide identical content about the crocodile. Inside, four *Digital Signs* containing distinct content are installed next to smaller enclosures housing insects, reptiles and frogs (Fig. 4). The opposite side of the enclosure consists of a glass wall which looks on to the lion enclosure.

The Philippines Crocodile exhibit aims to highlight the work of the zoo in protecting this endangered species. Accordingly, the *Digital Signs* at the crocodile enclosure provide information about conservation activities and how visitors can support them, along with information about the crocodile's diet, habitat and reproduction. The Signs offer a total of nine pages, the majority of which combine a photograph with one short paragraph of text. Pages are organised hierarchically into three categories, navigated using onscreen menu buttons, backwards arrow buttons and a Home button. Initially the Signs display a title page and three scale-shaped buttons for the three categories of content.

Inside the *DigestEd* space, *Digital Signs* adjacent to the small species enclosures act as species identification signs. Initially they display a front page with species name, an image and a short paragraph of basic information. One sign holds information about two species, both of which are represented on the front page. The subsequent page contains interesting facts about the species and a distribution map, and a third page provides an up-close photograph or video. Navigation is linear and uses on-screen arrows facing forwards and backwards, located at the bottom-right of the screen.

4.4.1. Aims and objectives

Digital Signs were introduced as an interactive and flexible alternative to traditional species labels. Through using digital screens as opposed to printed signs, interpretations staff hope to be able to more easily update signage and reduce the waste and effort involved in replacing static signs. This allows staff to readily update the exhibit displays as conservation messages change and animals are moved between enclosures. The design of the signs was shaped by the "conservation story" which had been mapped out for the precinct, and with the intent of highlighting key



Fig. 4. Digital Signs on the front wall of *DigestEd* (left) and inside *DigestEd* (right).



Fig. 5. The Zoopermarket installation in the visitor area of the orang-utan exhibit.

messages about the animals, their plight in the wild, and the zoo's related conservation activities. It is envisaged that in future interpretations staff will be able to update iPad content from their desktop computer, enabling greater flexibility in refreshing digital content in line with changes to the exhibit area.

Interactive touchscreens are perceived by some zoo personnel as a form of communication which is potentially more appealing to younger visitors than static signage. It is also perceived that interactivity allows content to be structured differently, avoiding the problems of presenting visitors with large quantities of text, and enabling use of engaging forms of media, including video.

4.4.2. Challenges and barriers to use

We observed that the majority of visitors to the *DigestEd* space do not interact with the *Digital Signs*, a finding which supported in our interviews.

"I have seen them used a little bit but not as much as I'd have thought" [12].

Very few visitors look at the Signs on the front wall of the space, which provide information about the Philippines Crocodile. Visitors looking at the small animal enclosures inside would often glance at the iPads to see what species they would find in the enclosure, but only a small proportion would touch the screen to access additional content. A number of factors were identified which could contribute to this, including the position of the Signs well below adult head height; reduced visibility of external Signs due to glare; and the possibility, raised by two interviewees, that many visitors do not realise the Signs are interactive. Children form the large majority of those who do use the Signs, however our observations indicated that most children swiped rapidly through the pages without engaging with the content; videos were an exception to this, as noted below. We did not observe any visitors take time to read the factual information about species presented on the second page of the Signs.

Deployment of the *Digital Signs* has presented technical and practical challenges. The first attempt to install the iPads on the external wall of *DigestEd* resulted in leak in the tank of the crocodile's enclosure; as a result, installation of these signs was delayed by several months. The goal of updating content on the

Digital Signs remotely has not yet been realised. At the current time, changing the content requires a technician to remove the *Digital Signs* from their housing and connect them to a computer. This causes delays to the update of digital content. For example, during our observations it was noted that the *Digital Sign* related to the tarantula received considerable attention, but the relevant enclosure now housed a mantis; this led to some disappointment amongst visitors.

4.4.3. System outcomes and perceptions

Some zoo personnel see interactive media as an inherently effective mechanism to engage young visitors.

"We talk about how to engage visitors, and obviously kids coming through the zoo are mainly digital natives, so [...] there is this idea of, 'oh well, we'll just get an iPad and the kids will use it'" [11].

It was observed that children who recognised the interactive nature of the *Digital Signs* and explored their content responded with enthusiasm to the engaging videos of animals in action (and to a lesser extent, up-close photos). In some cases, their interest prompted adults to look at the content with them. We noted that some children and intergenerational groups looked with heightened interest for the animals in the enclosure after watching engaging videos of the animal in action. However, in some instances, adults seemed to resist the use of the *Digital Signs*. On a number of occasions, we observed adults directing children's attention away from the Signs, encouraging them to focus on the animal in the enclosure rather than the digital content.

4.5. System 4: The Zoopermarket

The *Zoopermarket* (Fig. 5) is an interactive, supermarket themed display located in the visitor area at the centre of the orang-utan exhibit. The display is immediately visible to visitors entering the space but is located away from the entrance, on the far side of the glass walls which look on to the orang-utan enclosures. The *Zoopermarket* comprises shelves of consumer products, handheld barcode scanners and interactive touchscreens. When a visitor scans the barcode of a product the interactive screen displays information about the manufacturer's response to issues of palm oil

production. A traffic light system (red, orange, yellow–green, green) provides a high-level, comparative assessment of the manufacturer's response.

Users are encouraged to contact manufacturers whose response does not score highly: pressing the 'Act Now' button on the screen will enable them to send an email to the relevant manufacturer by entering their name, email address and postcode into the system using the touchscreen. Emails sent from the *Zoopermarket* are logged by the system; captured information is available to campaigns and interpretations staff. Zoos personnel liaised with manufacturer representatives during the planning and implementation of the campaign, and continually update assessments and displays to reflect actions and commitments from manufacturers.

4.5.1. Aims and objectives

The *Zoopermarket* installation is a central component of the Zoos Victoria's *Don't Palm Us Off* campaign focusing on production of palm oil in South-East Asia and its role in loss of animal habitats (Pearson et al., 2014). Located in the visitor space at the orang-utan exhibit, the installation aims to foster awareness about palm oil in consumer products, and generate consumer pressure on manufacturers to commit to improved labelling and using certified sustainable palm oil. In the terminology of the Connect, Understand, Act model, the installation is intended to help visitors to understand a conservation issue of priority interest to the zoo and enable them to take action.

4.5.2. Challenges and barriers to use

Commissioning and maintaining digital equipment in the orang-utan exhibit presented a number of practical challenges. Equipment was selected and constructed to avoid damage from misuse by younger visitors, and devices were housed in enclosures specifically designed to protect them from dust and other environmental contaminants.

There are concerns from some quarters that this playful installation makes light of the issues

"[Some] volunteers say, oh no – that's too kitschy, [...] we're dumbing it down too much." [V1].

Despite the perceived success of the installation, it is acknowledged that face-to-face interaction with zoo personnel is essential for visitors to fully absorb the campaign message, and to make connections between this issue and the animals on exhibit.

"Unless you explain it to them, a lot of the time people don't read all the signs that are around. 'You know palm oil is causing the destruction of habitat and it's affecting the orang-utans'; you have to say it to them for them to understand the connection" [V1].

Work to support campaign messages is considered an important aspect of volunteers' role; those who will work in the orang-utans visitor area are required to complete specific training. However, resource constraints and the fluctuating visitor numbers mean that at times the space is not staffed.

It is unknown what proportion of *Zoopermarket* users engage with the *Don't Palm Us Off* campaign. Our observations indicated that the majority of visitors who enter the *Zoopermarket* area take an active interest through reading signage, scanning displayed items or interacting with other members of their group who are using the system. However, during the course of our observations, totalling 60 minutes, no visitors were observed entering their details to send an email to manufacturers. It is recognised that a barrier to use is created by asking visitors for their email address, which prompts concerns around unsolicited mail. It is noted that visitors are more likely to send an email if personnel are present in

the space to engage them with the campaign.

"We know that face to face stuff always is a lot stronger than just something sitting by itself [...] we would love to have someone down there all the time interacting and engaging, and chatting to people" [I1].

4.5.3. System outcomes and perceptions

As a core component of the Zoo's *Don't Palm Us Off* campaign, the *Zoopermarket* is seen to have been highly successful (Pearson et al., 2014). This campaign is believed to have positively impacted manufacturers' attention to the issues of palm oil provenance and labelling, a fact which carries considerable weight for a volunteer:

"It wasn't until they actually started getting these emails that things started changing. I really like the fact that it worked." [V1]

It is considered to be an exemplary interactive installation, and is held up as a benchmark by zoo directors.

"It's fun, it's engaging, it delivers a really strong message, it's got a great action, it's a simple action, it's easy to do... [the CEO says] 'This is what we should be doing'." [I1]

From the perspective of the volunteer, the success of the *Zoopermarket* lies in its ability to draw children, and thereby families, to engage with the campaign message.

"Once the kids are in, flicking around, the parents are like 'what are you actually doing here?' and they read the information that pops up." [V1]

Observations and interviews confirm that children and parents are likely to interact together around the system. Younger children tend to play with the system, seeking products which will display a certain colour on the screen, without attention to the campaign messaging. However, slightly older children can in some cases be quite receptive to the campaign aims. It is believed that this in turn places pressure on parents to consider palm oil in their purchasing.

"Parents actually have to read up and read what it is they're doing." [V1]

Despite the need for in-person explanation, for an experienced volunteer such as the interviewee the *Zoopermarket* provides a means to start a conversation about campaign issues.

"You can say 'well come over with me and I'll show you how it works [...]' This is the connection with the oranges'." [V1]

However, some visitors are less receptive to campaign messages than others:

"They tune out when you start talking" [V1].

Thus, the volunteer tends to choose their audience carefully, and with sensitivity to the fact that some visitors see the zoo as a place of leisure and entertainment.

4.6. System 5: Apps for Apes

Orang-utans at Melbourne Zoo have opportunities to use an iPad as one component of their varied program of enrichment. Adult orang-utans have been trained to look at and touch the iPad, and are rewarded for engaging with the games and other apps. Apps offered include quick response games, painting and music apps. Enrichment sessions using the iPad are conducted while orang-utans are housed individually in the public viewing area or in their 'dens', a sheltered space not visible to the public. Sessions are conducted one-on-one by a keeper with an individual orang-

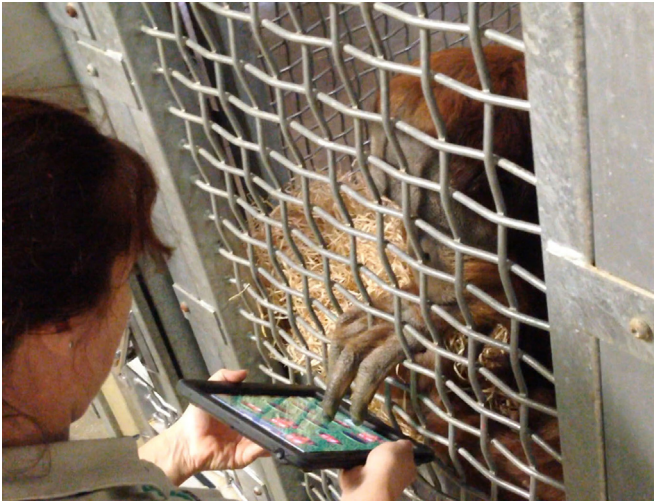


Fig. 6. *Apps for Apes* being used by adolescent male orang-utan.

utan. The keeper will open one of a number of apps found to be of interest to the orang-utan, and hold the iPad to the enclosure so that the orang-utan can touch the screen by pointing a digit through the mesh (Fig. 6). The keeper encourages the orang-utan to engage with the game both verbally and by demonstrating use of the app, and offers praise when they tap or touch the screen.

4.6.1. Aims and objectives

This initiative is inspired by *Apps for Apes*, a US-based program which promotes use of iPads by orang-utans as a basis for enrichment and to draw public attention to threats to the species' survival (Smith, 2011). Existing forms of environmental enrichment commonly require regular, time-consuming creation of stimulating objects using robust equipment such as playground apparatus, wire cages, balls, blankets and tarpaulins; these items are often packed with treats, wood wool and other fillers (Fig. 7). More creative and cognitively-engaging forms of activity are offered from time to time, including painting (Fig. 7), clay modelling, movie projections as well as use of the iPad. These activities are conducted both on display and out of public sight; for example, during one of our visits to the dens an animated movie was being screened for an orang-utan who was feeling unwell.

Keepers also see enrichment activities as opportunities to

demonstrate to visitors the animals' capabilities and "showcase them in relation to humans" [K]. It is anticipated that opportunities to see animals' intelligence at work can prompt visitors' empathy and respect, with the intent to "break down that divide between us and the rest of the animal kingdom" [K].

4.6.2. Challenges and barriers to use

Observation of orang-utans' use of the iPad reveals several physical limitations on their engagement. Reaching for the tablet through the mesh means that it is hard for the orang-utan to access much of the screen; this constrains the types of apps that can be used and limits their ability to interact freely with the device. It also requires careful finger-based touch, a form of interaction which does not correspond with their capabilities: "They're not nearly very good at fine motor control of their digits, that's generally a very human thing. But large, demonstrative movements - they're just as good at them as we are" [K]. It was observed that orang-utans often held their hands so that their fingernails rather than fingertips made contact with the tablet, meaning that their attempts to use the iPad were sometimes not successful.

Orang-utans are very interested in the iPad as a physical device, as it something they are shown but unable to take hold of. After a period of use, an animal may attempt to grab the tablet and becomes frustrated that they are prevented from taking it. The keeper may respond by offering a different app, but repeated attempts will generally lead the keeper to end the session.

4.6.3. System outcomes and perceptions

The two of the adult female orang-utans, the adolescent male and infant were found to look at and engage with the iPad when offered. The mature male is reportedly less interested in the iPad and one female has trouble using it because of an overgrown nail. Keepers have observed that individual orang-utans have marked preferences for different apps, and so tend to select apps accordingly. As the keeper is required to hold the iPad and support the orang-utan in using it, it is unclear to keepers to what extent orang-utans choose to use the iPad primarily to please the keepers, or as an opportunity for individual attention from a keeper. "If I was really experimenting with that I'd open the app and I'd slide it under the door and I'd walk away" [K]. Orang-utans are observed and reported to willingly engage with the iPad, but tend to use the device only for short periods of less than a minute at a time.

Despite the constraints on orang-utans use of the iPad, keepers are enthusiastic about the potential for interactive technology for



Fig. 7. Orang-utan enrichment activities. Treat-packed wire cages and tyre swings (left), painting (right).

enrichment and visitor engagement. Digital systems, including embedded or sensor-based forms of enrichment are seen as a means of increasing the breadth and novelty of stimulating activities offered to orang-utans, and supporting animal training programmes. Responding to welfare considerations of offering captive animals choice and control over their environment, keepers express an interest in connecting interactive systems with other features of the animals' enclosure, and in enabling video communication between groups of primates in different locations. We find that opportunities to see orang-utans using the iPad and engaging in creative activities hold considerable appeal for visitors.

5. Discussion

In this paper we have examined the use of interactive technology in a rich social context, exploring technology use as part of the organisational aims of the zoo, and in the context of interactions between diverse assemblies of humans and animals. In this analysis, we uncover implications for technology design, contributing to the body of ACI work which offers design considerations based on empirical studies of human-animal interactions (e.g. Aspling et al., 2015; Hauser et al., 2014; Paldanius et al., 2011).

Our case study investigated use of digital technologies at Melbourne Zoo by visitors (*Digital Signs* and the *Zoopermarket*), by zoo personnel with visitors (*Educator Screens* and *Volunteer iPads*), and by zoo personnel with animals (*Apps for Apes*). In this discussion, we identify themes which characterise the nature of the interaction as it occurs in a complex setting, shaped by diverse organisational and social forces. Firstly, we consider potential tensions between technology use and the expectations of visitors and zoos regarding the experience of viewing animals. Secondly, we discuss how technology deployment intersects with naturalism, widely practiced in zoo design. We then identify ways in which digital systems are transforming and extending the human-animal encounter to accommodate greater numbers of people across a wider area. This analysis gives close consideration to those aspects of the encounter previously identified as important to the zoo's objectives. Finally, we draw on these insights into human-animal-computer interaction in a complex social setting to develop further understandings of technology use as part of interactions between diverse groupings of visitors, zoo personnel and animals. This analysis responds to the call for ACI research to "consider the social organisation of the activities, rather than looking primarily at dyadic relationships between one person and one animal" (Weilenmann and Juhlin, 2011). From this, we identify five broad considerations for understanding and designing technology as part of socially-situated, multifarious human-animal interactions.

5.1. Technology as distracting from animal encounters

Introducing interactive systems to the zoo risks distracting visitors from the experience of viewing animals; an experience that motivates the zoo visit and zoos' engagement strategies. Despite the Zoo's desire to lead the sector and to attract public attention through innovation, it is generally considered that digital technology will only be a peripheral element of the visit, and that highly conspicuous technology runs the risk of diverting attention from the animal exhibits. Furthermore, we see indications that some technologies designed to support or augment the experience itself, for example by improving visibility, may interfere with important dimensions of successful human-animal encounters at the zoo. In particular, a visitor's sense of proximity to the animal, or of having had a unique animal experience may be disrupted by the

use of certain forms of technology to mediate encounters. This aspect of interactive technology use at the zoo is one that requires further investigation.

An important strategy used to avoid detracting from the animal encounter is to position interactive systems where they are unlikely to interfere with animal viewing. For example, presentations to school groups using *Educator Screens* are conducted before and after the zoo tour, in an area where few animals are visible. Similarly, when visitors reach the *Zoopermarket* it is expected that they have already seen the species associated with the palm oil campaign, including orang-utans - who may still be visible at a distance. On the other hand, some resistance to the use of the *Digital Screens* seemed to result from the fact that they were located in close proximity to animal exhibits, and thus diverted children's attention from viewing the animals. The strategy of deploying technology so that it is used before or after the animal encounter (temporally or spatially) can frame the experience through a specific interpretive lens and may extend the visitor's reflection on the animal, yet is unlikely to reduce the time spent viewing the animals or interfere with the experience of being in the animal's presence. As we will discuss further, the human-animal encounter is thus impacted by the introduction of digital technologies even though they are used by humans only, at a remove from the animal. These findings point to the need for ACI in other contexts to consider how human-only use of technology may disrupt interactions with animals, and how systems used at a remove from the animal can impact in subtle ways on human-animal relationships.

5.2. Technology as detracting from the 'natural' environment

It is apparent that the sense of being immersed in a natural environment is an important dimension of the zoo visit, and one which is impacted by certain forms of technology. The tendency towards naturalistic, immersive zoo exhibits has been driven by the understanding that seeing the animal in its 'natural' environment is preferred by visitor, seems to increase the time spent viewing animals, and may generate more positive impressions of the species and interest in its conservation (Ballantyne et al., 2007; Finlay et al., 1988). The presence of computer systems in this context could interrupt the sense of naturalism, with negative impacts on the sense of connection between the animal and its natural environment, and on the experience of immersion in the animal's habitat.

Animals' use of interactive devices, such as tablet computers, raises the prospect of similar conflicts between technology use and visitors' concept of the animal's natural behaviour (Wirman, 2013b). For zoo personnel, awareness that animals born in captivity have no knowledge of wild habitats means that such questions are subordinate to concern for the animal's wellbeing. Keepers adapt tools which might engage animals' cognitive abilities, regardless of their lack of resemblance to features found in the wild. Our observations indicate that visitors enjoy watching orang-utans engage in cognitively stimulating behaviour even when this involves non-naturalistic enrichment, such as wire cages and tarpaulins. This coincides with others' findings that report positive visitor perceptions of technology for both visitor and animal use (Perdue et al., 2012a). However, further work is required to understand to what extent and in what ways the presence of digital technology might impact the effect of naturalistic environments on visitor experience and education. Additionally, there are increasing opportunities to deploy tangible computing devices which blend seamlessly into naturalistic exhibits, and digitally augment existing enrichment devices and features of animal enclosures. It will be important to investigate visitor attitudes to the presence and use of naturalistic and embedded interactive systems

by zoo animals.

More broadly, the zoo is a space where people enjoy opportunities to get closer to nature, and enjoy physical recreation in outdoors settings very different from most of the urban environment. The findings of our study indicate that some visitors, particularly parents, are resistant to the use of screen-based technologies in this setting. This echoes concerns emerging from an examination of zoos' use of new media for education, conducted by Yocco et al. (2011). However, incorporating human technology into naturalistic spaces is a challenge which has been addressed in the design of a number of Melbourne Zoo exhibits. Many of the immersive precincts combine elements of the natural world (such as grassland, sand dunes, bamboo forest) with features of the human world which might be found within or adjacent to animals' habitats (such as dilapidated farm buildings, weathered rope, rusting roadside signs). Within these exhibits, digital displays and interactive systems tend to be integrated into those features which evoke the human world. For example, the *Zoopermarket* is built into the wooden cladding of the orang-utan visitor area, a space reminiscent of the interior of an Indonesian longhouse. Through this approach, naturalistic spaces such as the 'bamboo forest' remain free of technology. A future area of investigation will be to explore to what extent such approaches, and the use of embedded, screen-less technologies can be successfully adapted to successfully integrate digital systems into the zoo landscape. For ACI research more generally, it is important to consider how the appearance and contextual congruity of digital systems may impact on human–animal relationships.

5.3. Technology as transforming human–animal encounters

Our findings indicate that the use of technology as part of the zoo visit is transforming the encounter between visitor and animal in a number of ways. The deployment of interactive systems to represent and construct the animal – or interpretations of the animal – enriches the human–animal encounter and causes it to extend both temporally and spatially beyond the moments of physical co-presence at the animal exhibit.

5.3.1. Augmenting the encounter

Technology is being used at the zoo in ways which amplify a number of the dimensions of the animal encounter which have been identified as significant to the overall visitor experience, and associated with positive perceptions of animals and the zoo. The visitor's sense of proximity to the animal can be influenced by technologies of viewing, such as the *Educator Screens* and *Volunteer iPads*. As we will discuss further, these improve not only the visibility of the animal, but also create a powerful sense of intimacy with an animal which is present but at a remove from the visitor. Combined with the oral interpretation delivered by a skilled presenter, these can enable the visitor to simultaneously see up-close a rare or hard-to-see animal or behaviour, and understand its significance; this builds a sense of wonderment, and a sense of personal connection with the animal. On the other hand, these technologies do not contribute to the sense of being physically immersed in the same environment as the animal. Even when these systems are used in the presence of the animal, it seems that the sense of immersion is constrained, possibly due to the need to look back-and-forth between the screen and the animal.

Interpretive interventions also shape the affective dimensions of the zoo experience, employing personal narratives and engaging modes of delivery which stimulate visitors' curiosity and anticipation. Educators and volunteers are uncovering ways to use technology to draw on their personal interests and experiences in their presentations, showing visitors their own photos and videos of animals. More powerful still, educators' use of live video stream

to show interactions with the animal from their own point of view allows students the sense that they are enjoying a privileged insight into the secretive behaviours of small or shy animals. These approaches contribute to visitors' sense of wonderment and uniqueness, and – if well narrated – can construct a sense of personal connection with the animal.

The *Zoopermarket*, though not explicitly designed as an interpretive tool, also seems to impact on the visitor's sense of personal connection with the orang-utans. This may be effected through the opportunity to reflect on how personal consumer choices affect orang-utans in the wild. The system also provides a mechanism for zoo personnel to enter into conversation with visitors and thereby draw on personal narratives and create new connections.

One opportunity that has been little addressed at Melbourne Zoo thus far is the use of technology to support visitors' sense of animals' wellbeing. While Apps for Apes may contribute to animal wellbeing, this activity is rarely seen by visitors and would need to be carefully explained by keepers to be correctly interpreted by onlookers. We contend that there are important opportunities for zoos to make use of technology as a mechanism to address or highlight animal welfare needs in ways that are both apparent and engaging for visitors, thus shaping visitors' perceptions of animal wellbeing.

The Zoo is particularly interested in using technology to deliver powerful interpretive experiences to a greater proportion of visitors. It is envisaged that novel forms of interactive technology might support the visitor–animal encounter by mobilising the expertise and interpretive frame of zoo personnel in their absence. However, our observations of the self-service *Digital Signs* indicated that these contribute only to visitors' visibility of the animal and – in the case of one particularly compelling video – their sense of wonderment. Overall, this system did not seem to contribute to the visitor's sense of proximity, uniqueness or connection, and seemed to reduce the sense of immersion by distracting younger visitors. This suggests that it will be important to investigate whether well-designed interactive systems will be able to contribute to the sense of wonderment, uniqueness and personal connection which can be constructed by a live presentation.

5.3.2. Extending the encounter in space

The use of technology to provide an 'up-close' view of the animal from a distance was a theme that recurred throughout our investigation. This responds to the tensions that zoos face in balancing animal welfare with the aim of offering visitors opportunities for powerful animal encounters, through good visibility of the animal at close proximity (Fernandez et al., 2009). Used in this way, technology becomes an instrument of viewing rather than of communicating or accessing information. The viewer has the impression that the up-close view of the animal on the screen is something that they could be seeing in real life; this enhances the immediacy and the impact of the encounter, and can allow visitors to pose questions and reflect on the animal in ways that might not otherwise be possible. This parallels the forms of active engagement made possible by large screen displays at live sporting events (Ludvigsen and Veerasawmy, 2010).

Volunteers use iPads to shrink the distance imposed by crowds between the visitor and the animal; showing photos and video on the iPad to groups of visitors in turn allowed them to briefly 'get close to' the baby gorilla and mother. By increasing the visibility of the animal, the sense of encounter can be extended spatially to encompass a crowded exhibit area, a long queue of visitors, and even back-of-house areas of the zoo. This approach of directed-looking (Smith et al., 2010) has the effect of enhancing the experience of viewing an animal which is within sight but at a distance, or perceived to be just out of sight but nearby. Educators use iPads to similar effect by enabling students to view a close-up

video stream of an animal situated in front of them or in a room near by. In this instance, the use of technology offers not just a window into the animal's world but also a live, 'keeper's eye view' of the interaction between animal and educator. This allows the keepers to share the powerful dimensions of a close, dyadic animal encounter with a broader audience.

The ability to extend the encounter may have important benefits for animals, particularly species which dislike the close presence of numerous visitors. Through these technologies, zoos may be able to provide a high quality, powerful visitor experience and a sense of proximity while allowing animals to remain at a distance from visitors. Further investigation is required to explore how wider deployment of such technologies might benefit zoo animals. ACI has long been interested in the use of technology to enable pet owners to observe and interact with their animals remotely. Examination of the zoo context suggests a role for ACI to investigate how technology may augment in-person interactions, or enable remote interaction in settings where proximity is not desirable (for reasons of human safety or animal welfare). Thus, it is possible to mitigate the potentially negative impacts on the animal of the encounter with multiple people (Hosey, 2008), while preserving the beneficial effects on the visitor experience (Sherwen et al., 2015).

5.3.3. Extending the encounter in time

The majority of visitors interact with a specific animal for only a relatively short period, although zoo experiences prompt visitors to anticipate and reflect on their encounter with the animal in a number of ways. As part of this, technology is used to prepare visitors for their encounters with animals and prompt an extended period of reflection after the encounter. During introductory presentations, educators prime students for their zoo visit by displaying photographs of specific species. This provides a base level of familiarity to provide a foundation for a meaningful experience, and also builds students' anticipation of the animal encounter. Similarly, during the concluding session, educators use animal photographs while encouraging students to reflect on their encounters with animals. We contend that digital media combined with the educator's narrative provides a powerful sense of the animal as a continued presence, extending the audience's experience of the encounter.

We see similar effects in volunteers' use of iPads with visitor queues, combining high quality media with volunteer's accounts and explanations to provide a positive and memorable experience for visitors. Showing visitors historic media or contemporary images of animals relocated to other zoos might be used to call on and strengthen visitors existing connections with a species or specific animal. Such use of technology has much in common with other interpretive materials and experiences designed to prompt continued reflection on the animal, as expressed in the Connect component of as Melbourne Zoo's Connect, Understand, Act model and the reflective response observed by (Ballantyne et al., 2011). However, we contend that in comparison to static signage, engaging digital media has a greater ability to evoke the presence of the animal in ways which generate sensory and emotional impressions. These concepts could thus be leveraged as part of ACI initiatives aiming to maximise the outcomes of short-lived human–animal interactions in other settings, or promote positive ongoing relationships between humans and animals.

5.4. Technology as mediator of multiparticipant human–animal interactions

Studies of technology-mediated human–animal interactions and relationships, including much ACI research, has most commonly studied human–animal dyads. In contrast, we find that the

zoo is characterised by encounters between groups of humans (including visitors and zoo personnel) and diverse animals. Drawing on the preceding discussion, we identify several ways in which these interactions between numerous human and animal actors are already being supported by technology, and relevant challenges which remain to be addressed.

The zoo is a destination most frequently visited in social groups (with family, friends or institutional groups) and, in this semi-public space, it is rare for a solitary visitor to be alone at any given exhibit for any length of time. This means that human–animal encounters take place in the context of social relationships and behaviour, as explored by O'Hara et al. (2007), and as part of family outings laden with social and cultural significance (Hallman and Benbow, 2007). These social factors inform visitors' motivations and goals in interacting with animals, but the presence of other people (particularly at peak visiting times) can present physical limitations on visibility and proximity of the animal, and impede affective dimensions of the encounter, such as the sense of uniqueness and of affinity. Technologies such as the *Educator Screens* and *Volunteer iPads* are specifically designed to address the ways in which crowds can constrain visibility and proximity. However, zoo personnel are keen to identify ways in which mediating technology can promote a sense of affinity with the animal, and the sense of having a unique experience, despite the presence of other visitors at the exhibit.

As described above, zoo personnel are often involved in the visitor experience, and have a role in shaping or facilitating the animal encounter; activities which technology can support and extend. Interpretive interventions before or after the animal encounter are supported by tools such as the *Educator Screens* and the *Volunteer iPads*. Using *Educator Screens* to live-stream educators' interactions with animals provides a particularly powerful form of animal experience, made possible only through the skilful use of digital systems and the co-presence of animal, visitors and educator. Zoo personnel perform a variety of roles at the zoo, which are aligned with diverse, overlapping perspectives on the purpose of animal encounter, as a foundation for conservation, education, or visitor engagement. However, perspectives aligned to the conservation-oriented role of the zoo and animal encounter may at times conflict with the motivations of visitors focused on entertainment and family recreation.

Encounters may also involve multiple animals, as the majority of zoo exhibits house several conspecifics, either permanently or for certain periods. In some cases, animals' group behaviour has a particular appeal for visitors; for example, parents caring for their young, or the social interaction of primates. Human–animal interactions also occur in a setting where multiple species are exhibited, in a free-choice environment. Visitors' preference is for interaction with charismatic, entertaining and well-known species, resulting in crowds and exuberant visitor behaviour that can risk negative impacts on animals' wellbeing (Hosey, 2008). An important aspect of the *Educator Screens* and *Digital Screens* is their role of increasing the visibility and entertainment value of smaller and lesser-known species. We propose that broader use of digital technologies designed to augment and extend encounters, as described above, might enable visitors to enjoy powerful animal experiences while allowing animals greater control over their interactions with visitors, with positive outcomes for both visitors and animal welfare.

In the zoo context, dyadic interactions between a single animal and an individual human are not the norm. In our study of technology use, *Apps for Apes* provided one example of digitally-mediated dyadic interaction between a keeper and orang-utan. Some of the limitations of the *Apps for Apes* approach can be attributed to its one-to-one mode of use. Firstly, although the orang-utan is motivated by the opportunity to interact with the keeper,

the keeper is unable to fully participate in this interaction as their hands and attention are occupied by the iPad. Secondly, resource limitations mean that this time-intensive form of enrichment cannot be provided often or for extended periods. Lastly, individual keeper-delivered enrichments must be carefully managed to avoid jealousies and competition between animals. In response to these issues, we believe it is important to investigate alternative forms of technology designed for use by individual animals independently of keepers, and also to explore technology to support interactions between humans and groups of cohoused animals.

From the above discussion, we can identify several considerations relating to the nature of extended and social human–animal interactions, which are relevant to ACI research and design in diverse contexts.

- *Diversity of people and animals.* Whereas much ACI research and design focuses on the motivations and behaviours of an individual human user, in many contexts animals interact with multiple people (e.g. different zoo visitors). These people may have different levels of knowledge about the animal and how it should be cared for, and may have diverging expectations as to the role of the animal, or how it should behave and interact with its environment. Designers will need to accommodate these diverse interests on the part of humans, as well as animals' varied attitudes and behaviours towards humans.
- *Multiplicity of interactions.* At the zoo, but also in homes and on farms, animals tend to interact with multiple humans, often concurrently. Some animals may compete to interact with a human (for example, zoo animals with a keeper, or multiple pets with an owner). This calls for interactive systems which can accommodate or prioritise multiple users, but also indicates opportunities to moderate or manage competing demands for interaction.
- *Interactions are distributed in time and space.* When taking place between multiple humans and animals, interactions are not constrained to direct, face-to-face encounters. Rather, they may be distributed over time and space, and include participants who are not located with the others. Design of ACI technology thus needs to look beyond one-to-one remote interaction between pets and owners, to consider distributed, complex assemblies of humans and animals.
- *Interactions as part of diverse social activities.* Interactions between zoo animals and humans form part of diverse social activities, including family outings, school trips and conservation-oriented presentations. This points to the importance of considering the range of social groupings and behaviours that may play out around the human–animal encounter. This has particular relevance to interactions between dogs and owners, and human–animal working pairs (for example, guide dogs and other service dogs).
- *Interactions may involve performance.* Following from the preceding consideration, social activities and human–animal interactions are sometimes performed for the benefit of an audience. In some cases, these interactions may involve stage-management, scripting, or elements of ritual, which may have implications for the appearance and contextual congruity of digital systems. Such performances sometimes involve different roles and cater to diverse expectations and motivations.

In our study of the zoo we have examined interactions between – and in the context of – diverse groupings of visitors, zoo personnel and animals. This perspective has allowed a rich view of the intersection between technology use and interspecies encounters, looking beyond the motivations and behaviours of individual actors to consider the complex social and organisational context. Through this we indicate how ACI researchers can look

beyond dyadic forms of animal–human–computer interaction, and propose five considerations for accommodating encounters between diverse groupings of humans and animals.

6. Conclusion

In this paper we have explored the social dimensions of animal–human–computer interaction in a rich social context, through a case study exploration of interactive systems deployed at Melbourne Zoo.

As a setting in which great attention is paid to animal welfare and quality of life, and in which a central role is occupied by human–animal encounters for the purpose of improving interspecies relationships, the zoo provides a site in which there is considerable scope for exploring questions of central concern to the discipline of ACI (Mancini, 2011). The growing presence of interactive systems at the zoo provides the opportunity for ACI-oriented research to examine the interplay between technology, social forces and human–animal encounters. Through mapping the zoo as site of interaction between technology, animals and humans, this research offers a basis for further study in this context.

In our discussion we have investigated tensions between technology and the experience of viewing animals, and between technology and the 'natural' environment of the zoo. We propose that such tensions may be mitigated through design choices and through integrating technology with the naturalistic landscape of the zoo.

The study demonstrates how digital technology is being used to augment the human–animal encounter and extend the encounter temporally and spatially. We describe how interactive systems, including those used solely by humans and at a remove from the animal, are intervening in human–animal encounters in the zoo. These insights provide a foundation for future research and design at the zoo, a site of study which we believe will prove fruitful for addressing the goals and interests of ACI.

Finally, we reveal how technology at the zoo is being used in encounters between multiple humans and animals, and in the context of diverse social and organisational forces. Drawing on these insights, we discuss the broader implications for ACI pertaining to complex interactions between diverse assemblies of humans, animals and technologies. We identify five design considerations relating to complex human–animal interactions, contributing deeper understandings of how ACI can account for multiparticipant interactions and respond to the social contexts which bear on human–animal relationships.

Conflict of interest statement

The lead author's spouse is an employee of Zoos Victoria, the organisation that is the subject of this research.

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