Designing for intuitive use for non-human users

ABSTRACT

In the field of human-computer interaction the notion of intuitive use describes the extent to which a human user can subconsciously interact with a product by relying on existing knowledge from similar or identical situations. In animal-computer interaction (ACI) the idea of intuitive use holds great potential as it offers a way to conceptualize and further design better interaction. With the aim to inform better design for non-human animal users, this paper discusses how the notion of intuitive use can be applied to interaction design for animal users. The paper argues that tangible user interfaces together with knowledge transfer from other domains familiar to the animal may allow intuitive use of digital technology. Examples will be drawn from an ongoing game design research project which aims to build digital games for Bornean orangutans.

Author Keywords

ACI; intuitive use; digital games; interface design; tangible user interface; orangutan play.

ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces---Input devices and strategies (e.g., mouse, touchscreen); H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces---Interaction styles (e.g., commands, menus, forms, direct manipulation); H.5.2 [Information Interfaces and Presentation (e.g., HCI)]: User Interfaces---User-centered design.

INTRODUCTION

Non-human animals often perform tricks that differ from their 'natural' behavior and that go to great lengths in astonishing human spectators. Examples can be found in zoos, circuses, or on the city roadsides of less developed countries, for instance. Among others, non-human animals have been shown to maneuver the use of mechanical interfaces and, increasingly, computer interfaces. What such cases often share is that the individuals have been taught to do so.

This paper scrutinizes designers' possibilities to engage non-human animal users with less or no teaching and training. To unpack this, we discuss intuition, interaction, and intuitive interaction. The motivation for the research stems from a project in which digital games have been designed for captive non-human animals. Accordingly, the paper focuses on the use of digital interfaces and specifically digital game interfaces.

Digital Games for Orangutans

An ongoing game design research project aims at designing digital games for orangutan enrichment. The intended users are orangutans who have been rescued from illegal animal trade and are currently residing in dedicated rescue centers in Indonesia. Some of the apes may be released back to their natural living environments, while many of them will never learn the skills needed to survive in the forest and will therefore stay in captivity. The project aims to build games that will enrich this life in captivity be it temporary or for a lifetime.

Initially, the project relied on games designed for touch screen computers. The platform was chosen as previous research suggested successful use of touch technologies in orangutans and other great apes due to similarities in hand-structure, sensory function and memory. However, early on in the project it became clear that some degree of teaching would be necessary for securing safe and efficient use of touch computers design of which originated from the expectations for human use.

The project faced challenges both in terms of offering suitable training for the non-human animals and in accepting that most games were not readily available for their use and interaction. While we acknowledge that research in other fields, such as comparative psychology, has successfully achieved training great apes in the use of various game-like interfaces, this was not in line with the aim of our project that focuses on igniting the intrinsically motivated behavior of play as we know and define it.

The kind of learning that takes place in relation to gameplay can be separated into learning that takes place before the player engages with actual in-game elements and into learning that is related to characters, objects, storylines, events, sounds, and other aspects of the game itself. The former kind of learning is about how to start a game, how to efficiently control technology using its physical and digital interface elements, and how to successfully receive and interpret feedback given by it, among others.

In the following we focus solely on the kind of learning that is a prerequisite for any game application – learning of the general interface of a specific hardware and software setup. To offer an example of a human user, a person needs to learn how to operate a handheld controller and how to link sound, visual and vibration feedback with each other if she is to play a game using a PlayStation 4 game console. She also needs to learn the game-specific controls for, for instance, moving a character or shooting a monster. Meanwhile, a non-human animal user without any personal or cultural understanding of game controllers let alone PlayStation would also need to learn not to use excessive pressure on the fragile controller, which way to hold it, not

to obstruct screen view with dirt, and to simultaneously observe happenings on the screen while controlling virtual objects with a controller, etcetera.

This simple example alone serves to illustrate how fundamental are the differences in expected learning content between non-human animals and humans. The differences result from a gap in personal and cultural backgrounds in understanding the intended use of technologies that humans have originally designed for humans.

Intuitive Use and Learning

User intuition is a concept that signals easiness and effortlessness of use in the context of design. Looking at how the field of interaction design aims to provide intuitive experiences for intended users helps to unpack what exactly goes into learning to use an interface.

Specific guidelines and design principles have been proposed for the design of interfaces that allow for intuitive use. However, such guidelines and design principles are largely based on human interaction and information processing and do not therefore seamlessly apply to the design of digital applications for non-human animal users. This is because social and cultural contexts often provide users knowledge about correct use of technologies. For instance, we may assume from past experience the basic functions of a digital tape recorder without using one beforehand. Popular culture, advertising, and observations of other users also offer us hints about how to meaningfully approach an interface.

Drawing on examples from the (Blinded) game design research project, the latter parts of this paper will explore possibilities for applying intuitive design of animal-computer interaction (ACI) [10] in general and game design for non-human animals in particular. We argue that the idea of intuitive design relies on knowledge of human information processing that cannot be readily applied to non-human animals. It is nevertheless not within the scope of this paper to study orangutan information processing. Instead, our design method relies on observation of orangutan play both with and without technological enhancement. Based on these observations we come to suggest examples of the kinds of interfaces that have the best potential in affording intuitive interaction for orangutans.

HUMAN INTUITIVE INTERACTION

The idea of intuition in interaction design has undergone significant changes over the last twenty years. In 1994, Raskin argued that an interface is intuitive if it resembles or is identical to something the user has already learned. He further suggested that the word intuitive may advantageously be replaced with the word ‘familiar’. [13] Raskin’s idea of an intuitive or familiar interface does not therefore imply that the user should be able to understand how to interact with an object without any prior exposure; on the contrary, if an interface is intuitive the user may very well have familiarized herself with an identical or similar interface at a previous occasion.

It thus becomes clear that whether an interface is intuitive to use or not completely depends on the user’s existing knowledge and skills. Be it a trivial fact when humans are in question, in relation to animal-computer interaction it is crucial to stress that intuitive interaction does not draw solely from innate behavioral patterns such as reflexes. For instance, considering orangutans as users necessitates focusing on individuals instead of their species at large because significant differences exist between both personal histories and ACI contexts of orangutans.

While Raskin writes about intuitive interfaces, many researchers have later argued that ‘intuitive’ is actually not an attribute of an interface but of interactions with an interface [9, 5]. Blackler, Popovic and Hahar, among others, propose three principles for the design of interfaces that are intuitive to use. According to them 1) the designer should use familiar labels and icons in familiar expected positions, 2) functions that are unfamiliar should be represented using image schemas or familiar metaphors, and 3) functions, appearance and location of functions should be consistent in different parts of the system so that the user can draw on the same knowledge in different parts of a product [1].

The interdisciplinary research group IUUI (Intuitive Use of User Interfaces) introduces an idea of subconscious information processing as a necessary requirement for intuitive use [9] and thus emphasize that an interface should not only be familiar to the user, but the user should also be able to interact with it without conscious effort. They further argue that such subconscious processing depends on four factors: 1) that the user can automatically recognize the functional properties and current state of the interface, 2) that the user can automatically predict the behavior of the interface and its response to the users input, 3) that the perceived object's behavior and the users own motor behavior match with the simulation and 4) that the simulated motor behavior is automatically executed by acting, manipulating objects and moving oneself [3]. According to IUUI, this can be achieved through interaction with physical interfaces, which is typically processed subconsciously in humans [9].

Usability and Intuitive Use

As the review above suggests, intuitive use is closely related to the notion of usability. Contrary to intuitive use, usability is standardized by ISO (ISO 9241-11) as “the extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” [8]. While usability should ensure effective interaction, the concept does not address mental efforts. Designing for intuitive use thus specifically focuses on reducing the mental charge of

an interaction while other variables such as time and physical effort are of lesser importance [5].

Tangible Interfaces

Physical or tangible user interfaces (TUI) allow more direct interaction and manipulation of digital information than a graphic user interface (GUI) of conventional computers [7]. While devices that support GUI interaction, e.g. a keyboard or a mouse, are also physical objects, they nevertheless rely on metaphors to guide interaction. The user's click to open a folder is a symbolic and highly abstract interaction that does not in any way resemble an actual interaction between a human and a physical folder. Touch screens, meanwhile, offer a possibility for more direct tactile interaction, it is nevertheless guided by similar kind of metaphors.

In comparison, TUI couples digital information with everyday tangible objects. The objects and the user's hands-on manipulation of their parameters are part of an underlying digital simulation that due to the physical embodiment of the interface are perceived by the user's peripheral senses [7]. It thus requires less mental effort and can therefore be considered intuitive [9].

Closely tied to the idea of the user's familiarity with an object is the idea of affordances. Gaver suggests that affordances are the properties of an object that make possible some action to a user equipped to act in certain ways. [2]. Only if there exist perceptible information about an affordance, can it be perceived by the user. This of course depends on the user's mental and perceptual capabilities [2].

A GUI on a touch screen computer may not provide an orangutan user with any perceptual information that reveals its affordances because the orangutan may not be equipped with the linguistic, cultural, and perceptible skills needed to perceive and process this information. A physical object such as a branch, on the other hand, may provide the orangutan with the perceptual information about the affordances of the object. Interaction with the branch can accordingly be considered more meaningful from the point of view of the orangutan than interaction with the GUI.

Whilst aiming for intuitive use, we suggest that designers identify the ways in which a user interacts with a physical object and how the specific affordances relevant to this interaction are being communicated to the user. The designer can then apply this knowledge in the design of a TUI and the perceptual information about relevant affordances.

ORANGUTAN INTUITIVE INTERACTION

Significant challenges lie in applying Blackler, Popovic and Hahar's three design guidelines in the design for animal-computer interaction. While the first principle suggests labeling functions, this is only relevant if the user can make sense of symbols such as words. While some studies have shown that great apes can be trained to use symbols in cross-species communication, this is a result of vast training [18], and we argue that too much effort will likely be put into this task to truly call it intuitive.

The second principle is more interesting since it advocates for the use of image schemas and familiar metaphors. Research shows that a great variety of image schemas are indeed available to non-human animals. An analysis of the mimic behavior of an octopus shows that this behavior applies to many well-known image schemas such as the containment schema, the part-whole schema, the verticality schema among the more well-known [3].

We believe that these image schemas are of great interest to the ACI-field since they are part in structuring the non-human animal's interaction with technological artefacts. However, in interaction design the idea of image schemas is often applied as conceptual metaphors [5]. When a user increases the volume on a computer moving an icon up along a slider the basic verticality image schema is involved as well as the conceptual metaphor more is up, less is down [5]. While non-human animals may apply various image schemas, to our knowledge no research has suggested that the conceptual metaphors derived from image schemas are graspable to non-human animals, and the application of image schemas in the design for intuitive use is thus still limited.

The third principle suggested by Blackler, Popovic and Hahar seems the most applicable to orangutan ACI. According to this principle, the designer must ensure consistency across the system. The idea of consistent functions and locations seems not to rely on specific human cognitive skills, and we therefore argue that this can prove useful when designing for intuitive orangutan use.

Subconscious Processing

The idea of subconscious processing as a prerequisite for intuitive use is likewise problematic when it comes to non-human animals. The notion of animal consciousness is a highly debated area [18] that we do not wish to address directly in this paper. However, when IUUI uses the notion of subconscious processing they refer to processes that require as little cognitive effort as possible [9]. So while we try to avoid questions of consciousness or sub-consciousness in orangutans, we see no reason not to believe that the cognitive effort used to perform a certain task will not reduce with the number of times this task is performed. The four factors for subconscious processing, put forth by Israel et al. [9] become relevant in regard to orangutan-computer interaction even though this interaction may not be characterized as subconscious per se.g

The idea that the user should be able to recognize functional properties and predict the behavior of an interface is particularly interesting in relation to orangutan users. Namely, research in animal cognition suggests that Bornean orangutans can indeed simulate interaction with an object and it is suggested that this ability is used when traversing the tree tops. As this kind of movement can be highly

hazardous if a branch is not strong enough to carry the orangutan or not long enough to bridge a gap between to trees it is of utmost importance that the orangutan is able to predict the behavior of the branch and simulate the interaction with it before proceeding [15]. An experiment involving a puzzle box even suggests that orangutans can use procedural rules to achieve certain goals and that these rules are applied flexibly in accordance with the configuration of cues in a given trial [15].

Mapping

Here coupling of digital information with physical object poses some challenges to the design of a TUI. Assuming that an orangutan may be able to perceive functions and plan how to interact with objects using knowledge acquired from other domain, it can nevertheless be difficult for a researcher to ensure that the outcome of this interaction makes sense to the orangutan. The problem relates to how digital information and functions are mapped on to the physical interface of the system. While physical objects may suggest certain interactions to an orangutan, the system is not intuitive if outcome does not relate to the interactions in a way the orangutan user can recognize and predict [9].

DESIGNING FOR INTUITIVE USE

We suggest that to successfully design for intuitive use of digital interfaces, the designer can seek help from other domains than ACI in order to find orangutan-object interactions that can be applied to interface design. While so doing, we argue that it is important not only to pay attention to the interaction in itself, but also to the context in which it takes place. If an orangutan throws a branch as a means to express agony towards another individual, this knowledge can inform the design of intuitive TUI.

To achieve TUIs that are intuitive to non-human animal users we suggest the following recommendations: 1) the objects and interactions should be familiar to the user, 2) the perceptual information that communicates available affordances must perceivable by the individual user, 3) the mapping of digital information to the physical objects must be meaningful and consistent across the system, and 4) the interface must allow the user to simulate or plan the interaction.

Tool Use and Object Play in Orangutans

In order to examine how knowledge from other domains can be applied in the design of physical interfaces, we present a list of orangutan interactions with physical objects. However, as previously mentioned, we are designing for specific orangutans and can therefore naturally not assume that the knowledge of one individual is necessarily available to other subjects. The following lists provide a set of possible interactions that a designer can use when identifying interactions in individual orangutans.

The following types of tool use have been reported in orangutans [14]:

- Branches or other objects are dropped or thrown in agonistic contexts or to draw the attention of conspecifics.
- Branches are waved as part of agonistic display towards other individuals or for cooling.
- Various objects such as a piece of bark, a stick are used for hitting other individuals.
- Homemade tools made by branches or sticks are used to open fruit or other solid objects
- A stick is used as a hammer to blunt the spikes of a durian fruit.
- Sticks or similar objects are used as levers or to pry objects loose.
- Sticks are used as shovels to dig with.
- Sticks are used to poke other individuals or to poke in food that would otherwise be out of reach.
- Long sticks or other objects are used as a hook to rake in objects that would otherwise be out of reach.
- Sticks, often operated with the mouth, are used to probe insect nest or fruit.
- Piles of leaves or other objects are used to block the flow of water.
- Boxes have been stacked to reach suspended food
- Hollow objects or shells are used as containers or ‘drinking cups’.
- Cloth, branches or big leaves are used as ‘blankets’ to cover oneself or other objects.

The following un-exhaustive list contains types of object play have been observed in two orangutans [17].

- Operating touch screen computer with tongue and lips.
- Operating touch screen computer with one finger or with two fingers simultaneously.
- Touching the touch screen computer with palm of hand (but not operating it).
- Exploring touch screen computer with fingers (but not operating it).
- Pressing muzzle area against screen of touch screen computer.
- Banging touch screen computer with a fist.
- Stroking touch screen computer with legs.
- Rubbing food on touch screen computer.
- Pouring liquid on touch screen computer.
- Exploring human body parts with fingers.
- Pulling cables.
- Poking humans using sticks of wood.
- Exploring bars of the enclosure with tongue and lips.

While many of the listed interactions are directed towards the touch screen computer, we argue that they may not necessarily have been direct attempts to operate it. Nevertheless, they do suggest possible interactions that may

be familiar to the orangutans and that can therefore be applied in the design of a TUI that aims to be intuitive.

Application in Game Design

The lists presented above provide us with a great variety of interactions that can be applied in our game design project. Many of the interactions such as stacking boxes, poking with a stick, or pulling cables immediate seem suitable in the design of control interfaces.

The first step to design for intuitive use is to ensure that the technology recognizes and responds to the users input. As the first step, control interfaces designed for intuitive use should therefore accommodate interaction with fists, palm, multiple fingers, lips, tongue, or other body parts that the above list suggests are intuitively used by the orangutans [17].

Mapping the digital information with the physical objects is the next step in design. To do this, we suggest considering the original context of interaction. If throwing objects in the original context of the interaction is supposed to scare of other individuals, one could for example think about a very simple sensor-based game where various objects appear on a large screen but disappears if the orangutan player succeeds in throwing a soft object such as a ball against the screen. This way the digitally mediated outcome of the game would match the intended use of the physical control interface of the game.

While some objects may have many different possible interactions (and affordances), we argue that the original context of use can point the player towards an appropriate way of interacting with an object in the current context. An example could be a game where the orangutan must rake in objects using a stick. Since the stick has many affordances, the perceptual information available does not necessarily communicate how it should be used in a given context. The player may for instance throw the stick instead of using it as raking tool. To avoid such 'misuse' from happening, designers can incorporate characteristics from the original context to the perceptual information about the physical objects. The above lists suggest that raking involves objects that the orangutan player desires, whereas throwing could be done to scare other individuals. The designer can therefore think of ways to make the objects that must be raked desirable for the player instead of threatening so the orangutan intuitively uses the available stick as a raking tool.

In another game designed for orangutans, orangutans' observed interest in poking objects residing outside of their cage with wooden sticks was utilized as a basis for design. In the game an orangutan can poke a stick though a pierced wooden panel creating sounds based on the hole in which a stick goes into.

DISCUSSION AND FUTURE RESEARCH

The aim of this paper has been to discuss the possibilities of designing for intuitive use of digital interfaces for orangutan users. The concept of intuitive use in human-computer interaction heavily relies on knowledge on human cognition and information processing and further suggests that the design for intuitive use must address specific species. The presented field studies suggest that what may be intuitive to one species may be very contra-intuitive to another. To our knowledge, no research has approached orangutan cognition and information processing to an extent sufficient to formulate a complete framework for designing for intuitive use in orangutans.

Areas of particular interest for future study are orangutan image schemas that can be applied in the interface design, the cognitive effort employed in object interaction, if and how knowledge is transferred from one domain to the other, and if ACI becomes at some point familiarized and internalized. Only when answers to these questions are available, proposing a complete framework for designing for intuitive use of digital interfaces becomes possible.

Next steps for the presented research include exploring the role of the more instinctual behavioral patterns in the design for intuitive use. While we argued that the use of the idea of subconscious processing in intuitive use for non-human animals is problematic, instinctual behavior may very well be a useful analogue to subconscious processing in non-human animals.

CONCLUSIONS

This paper has discussed how designers can engage non-human animal users with less teaching and training. The paper has focused on how we can design for intuitive use and how this may be done in relation to game design for orangutans.

Following existing theories from the field of HCI, we suggested that intuitive use in non-human animals is interaction that requires as little mental effort as possible and furthermore that TUIs may allow interaction that is internalized and thus less resource-intensive in terms of mental workload.

TUIs should allow for interactions that are familiar to the orangutan from domains other than ACI. In order to efficiently engage non-human animal users, designers can pay attention to ensuring that affordances are communicated to intended users and that the mapping of digital information on physical objects is both consistent and meaningful so that the user is able to plan and simulate the interaction.

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