Playful Animal-Computer Interactions: a Framework

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You can discover more about a person in an hour of play than in a year of conversation.

--Richard Lindgard

Beyond individual cases and uncontrolled opportunities, non-human animals have been interacting with human technology at least since the sixties, when Skinner's behavioral experiments required animals to interact with interfaces of operant chambers and when animals were made to wear tracking devices in conservation research. In zoos, primates in particular were provided with computer technology as a form of environmental enrichment already in 1970s as Markowitz and Yanofsky (1978) introduced a speed game for captive mandrills to play against human visitors. Today, the emerging discipline of Animal-Computer Interaction (ACI), introduced by Mancini (2011), promotes a fundamentally user-centric approach – both in terms of methodology and theory – in the design of technology for animals and is largely informed by the conventional wisdom available in the various sub-fields of HCI.

In the spirit of user-centric interaction design, non-human animals' playful interactions with technology draw increasing attention within the ACI community. Designing play stems from the objectives of various animal welfare initiatives in providing environmental enrichment for non-humans in captivity as well as from the interest to gain closer ties with companion species. In behavioral science, play has long been identified as a potential welfare indicator because it often disappears when animals are under fitness challenge and because it is thought to be accompanied by a pleasurable emotional experience (Held and Špinka 2010). Therefore, playful interactions have the potential to improve captive animal well-being at homes, zoos and beyond by providing cognitive enrichment as well as physical exercise, or to serve creating stronger bonds between humans and non-human animals. Moreover, as non-human animals perceive technological devices in completely different ways from humans, understanding these differences have the potential to lead to exciting new insights into the nature of play itself (cf. Wirman, Smits, Yu and Yuen 2011).

What kind of play may playful ACI involve?

Behavioral research distinguishes between three main types of animal play: social play (Burghardt 2005), locomotor-rotational (alone or in company, see Wilson and Kleiman 1974) and object play (Fagen 1981), which means interacting with inanimate objects.

While several ACI projects have addressed the design of technology for mediating or creating bonds between humans and non-human animals, our main focus here is on *direct* interactions of an animal with a device, for which the most relevant from the above mentioned categories of animal play is that of object play. In what follows we briefly review some illustrative examples of recent ACI studies, which will be later used in the discussion of the framework presented below.

Technologies for Non-Human Animal Play

Geurtsen et al. (2015) introduce a digital interactive game which they designed for the entertainment and cognitive stimulation of dogs staying alone at home. The device consists of two audio speakers and corresponding buttons to be pressed by dogs' paws, and an electrically controlled dog treats dispenser positioned midway between them. In its turn, each of the speakers plays a sound, and the dog is supposed to press the button corresponding to it. If pressed correctly, food is automatically provided by the dispenser. The participating dogs were domestically tested over the course of 30 days during which twice-daily saliva samples were analyzed for cortisol stress hormone concentrations. Combined data confirm that digital interactive games can lessen physiological and behavioral stress responses in dogs, and that the effect is modulated by a dog's personality.

Wirman (2011; 2013b; 2014) discusses a project for captive orangutan enrichment and cross-species interaction implemented at a wildlife rescue center in Indonesia. Progressing from touch screen play to tangible digital interfaces, several game types and technologies were provided to Bornean orangutans in experiments aiming at recognizing preferences, affordances, and playing styles characteristic to orangutan play. Drawing on examples from *TOUCH* project, Wirman and Jørgensen (2015) advocate co-design approaches and extension of orangutans'

existing play practices by digital means instead of the introduction of unfamiliar interfaces and affordances.

Westerlaken and Gualeni (2014) developed a tablet game, called *Felino*, which aims at facilitating the emergence of 'play' between humans and domestic cats, and allows humans and animals to play together simultaneously. The cat's reactions and preferences were taken into account during different phases of the design process. During user testing a behavioral analysis of video observations was performed and systematically analyzed using video coding software. The authors propose to measure bodily signs and relative changes in bodily dimensions with metric and/or biometric analysis of the animal's interaction with the artefact combined with an ethnographic approach in order to move away from solely subjective interpretations.

Metazoa Ludens allows pet owners to interact and play with their hamster remotely via the Internet in a mixed-reality game (Cheok et al. 2011). The hamster is placed on an actuated flexible door and presented moving food that it physically chases and catches. In virtual game space, the human avatar is coupled to the physical food, while being chased by the hamster's avatar. After being allowed over a period of six weeks to voluntarily play for one hour per weekday, standardized body condition scoring showed that hamsters' health and fitness had improved. A separate study, aimed at assessing the motivation of the hamsters to play *Metazoa Ludens* showed that over time the hamster's preference to play increased.

Baskin and Zamansky (2015) constructed an ethogram (a catalogue of observed behaviors) for dogs interacting with tablets during a "catch an object" game, based on *YouTube* video footage, as well as a controlled experiment. One of the conclusions was that some behaviors indicate the potential for stress and aggression of some dogs during such interactions.

Towards Shared Vocabulary (and Theory)

The design and analysis of playful ACIs, or 'ACPIs', as a scientific topic remains in its infantry. It calls for multi-disciplinary approaches from ethology, interaction design, user-computer interaction, and media and game studies. These communities, however, use radically different research methods and theoretical frameworks. Due to the rapid emergence of the specific topic

of study, parallel and overlapping terminologies have been developed, too. Establishing a shared discourse is potentially challenging and poses a need for a unifying conceptual ground.

What is an ACPI, how can we recognize it when we see it, and what are the guiding principles that should inform the design of such interactions? To the best of our knowledge, no widely accepted definitions of ACPI are yet available. Pons et al. (2015) proposed a general definition of an "intelligent playful environment" as "an animal-centered ecosystem with intelligent capabilities which is able to learn from the animals' behaviors and interactions, using the acquired knowledge to adapt itself to the context, creating engaging playful activities which do not necessarily need human mediation to evolve". However, this definition addresses only the side of the device, leaving the animal out of scope. Moreover, notions of animal's interaction (with device/environment) and engaging playful activity still require clarification.

In what follows we propose a general conceptual framework for describing, analyzing and comparing playful ACI interactions (ACPIs), which is grounded in a definition of animal play from behavioral science. Within this framework we attempt to reconcile various notions and elements of play interactions from existing ACI research.

Animal Play, a (Working) Definition

Play interaction is one of the most natural ways for animals to gain new experiences and include new objects – as well as other individuals – in their perceptual world. Play is seen particularly important for young mammals in several aspects: practicing skills they will use as they grow, such as hunting and fighting behaviors; reinforcing social bonds; establishing hierarchies by understanding their own physical limits and those of others; and exercising. Burghardt's (2005) five essential criteria are standardly used in behavioral science to describe animal play:

1. a behavior that is not 'fully functional' (by this is meant it includes elements 'that do not contribute to current survival')
2. it is 'autotelic', that is self-rewarding (and so related to experiencing 'pleasure')
3. differs in structure and/or timing from the adult, 'serious' form of the behavior

4. is performed ‘repeatedly’, but not stereotypically
5. is initiated when the animal is in a ‘relaxed field’ (by this is meant there are no immediate threats to the animal’s fitness).

While game design for non-human animals is at a stage of individual pilot projects and proofs of concept, it becomes meaningful to compare the above characterization with various definitions found in the literature that scrutinizes human play instead. Such theories have long served in the field of game studies to provide a theoretical basis for analyzing as well as designing play experiences. Caillois (1961), for instance, defines play as “a voluntary attempt to overcome unnecessary obstacles“ and characterizes it as free, uncertain, unproductive, and separated by its own time and space. For Huizinga (1964), play is something non-serious, yet utterly absorbing and stands outside ordinary life. Nearly a hundred years ago already, Ducasse (1966) defined play by its autotelic characteristic. Just like in Burghardt’s postulation, Ducasse sees that play is intrinsically motivating. We consider such obvious overlaps in theory a viable starting point for a conceptual framework of animal play.

ACPI, towards a Framework

Drawing inspiration from Burghardt’s definition of animal play, we take animal behavior as our basic notion. In animal science, behavior is a reaction to stimuli of the animal’s *environment*.

Another part of the framework is a technological *device,* which is placed in the animal’s *environment.* In reaction to *input*, the device produces *output in the form of sensory stimuli*, which are part of the overall stimuli of the environment. The animal displays *behaviors*, which are responses to the environmental stimuli.

Some of these behaviors are functional (the exact classification is species-specific) and some are non-functional. A subset of non-functional behaviors may be device-oriented (e.g., touching the screen). The environmental stimuli also affect the animal’s state (both physiological and emotional), some parameters of which can be measured. Among other things, they may threaten or distract the animal, taking it out of its `relax zone’.

An *ACPI iteration* starts with the device's stimuli, which trigger a set of behaviors of an animal, some of which are device-oriented and again produce new digital output. ACPI is a sequence of such iterations, which has, in addition, the following characteristics that we draw from Burghardt and definitions for human play:

- The stimuli produced by the device are not externally rewarding for the animal (and so its device-oriented behavior is self-rewarding).
- The stimuli produced by the device positively change the state of the animal (reducing stress, making it feel happiness[1], and thereby potentially improving its welfare.)
- The behaviors which are not device-oriented are not triggered by environmental stimuli that threaten or distract the animal (the animal is in 'relax-zone').

We illustrate the above by using an adaptation of a classical human factors interpretation of the human-machine interface from (MacKenzie 1995), in which a loop is created between a user and a machine via interacting with an interface. Adapting this idea to our setting, we obtain the framework presented in Figure 1.

ACPI is, therefore, the loop in the diagram, created between an animal and a device: the animal is in relax zone, and exhibiting non-functional behavior towards the device, which in its turn produces sensory stimuli which affect the animal's state and behaviors.

When examining a particular ACPI interaction, the framework gives rise to the following "checklist" of characteristics:

1. **Animal:** *What is the set of envisioned/possible device-oriented responses of the animal?* This can be answered, e.g., via analyzing video footage and constructing ethograms (e.g., Westerlaken and Gualeni 2014, Baskin and Zamansky 2015, Geurtsen et al. 2015).
2. **Device:** *What is the set of sensory stimuli produced by the device?*
    a. *In what way are they rewarding for the animal?* In this context interactions by Geurtsen et al. (2015) and Cheok et al. (2011), where food is offered to animal

[1] Note that our choice of the term "happiness" instead of "pleasure" is not accidental; happiness is one of the universally acknowledged six basic emotions.

during the interaction can be compared to Westerlaken and Gualeni 2014 and Baskin and Zamansky 2015, where the animal tries to catch a moving object without any obvious reward (except for satisfying a hunting instinct).

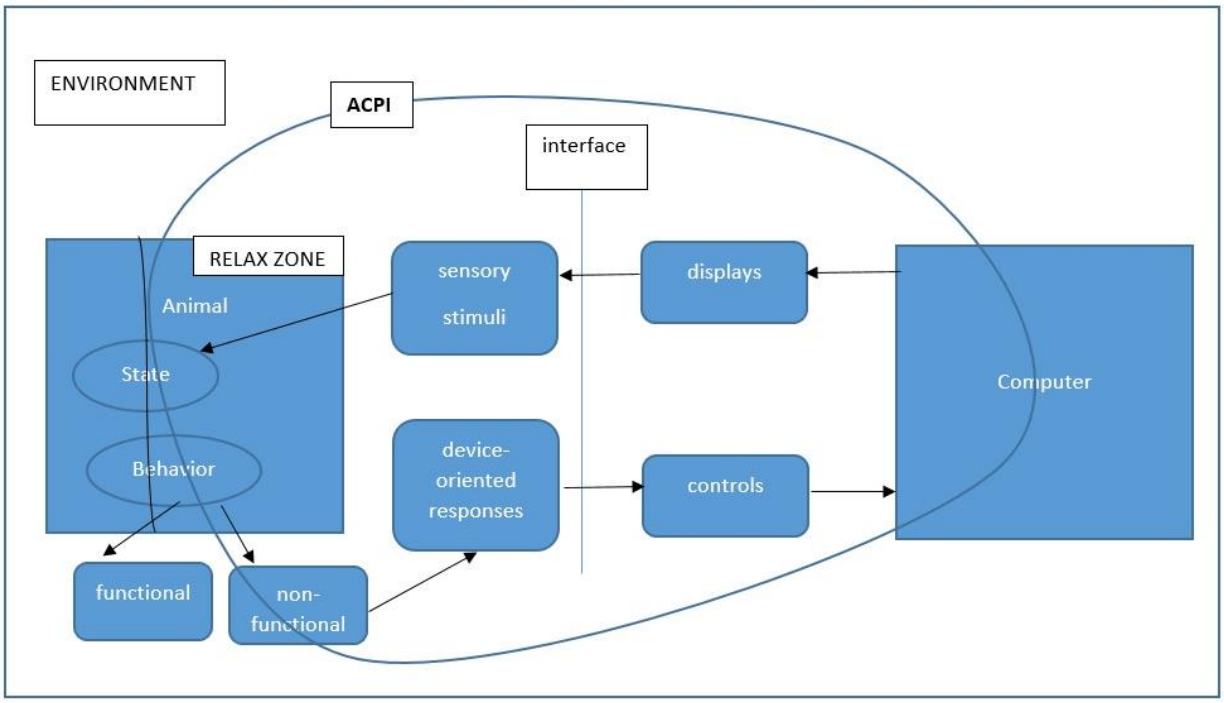

Figure 1: A framework for ACPI

b. *What is their expected impact on the animal's state? What are the possible ways to measure and assess it?* A notable work in this context is Geurtsen et al. (2015), where dog saliva samples were analyzed for cortisol stress hormone concentrations; the results indicated a reduction in cortisol levels, indicating reduction of stress. Other possibilities include various wearable sensors, as proposed by Pons et al 2015.

3. **Environment:** *What are is the sensory stimuli produced in the environment? How can they be reduced so as to bring the animal as close as possible to its 'relax zone'?*

a. *What are the existing environmental factors contributing to the animals' stress level and to which extend these can be reduced?*
b. *How are caretakers and everyday routines fitted into the research context?* Wirman, among others, discusses the distractions present in a rescue center including weather conditions, feeding patterns and volunteer presence.
c. *How is technology introduced to the animals?* Wirman further introduces how supporting technologies can create excitement. Anxiety caused by new technological artefacts and items brought to the animals' living environments is also possible.

Summary and Future Work

We have presented a general framework which is grounded in concepts from animal behavior science. Using this framework, we have proposed a characterization of ACPI which reconciles Burghardt's definition of animal play with various notions and elements of play interactions from existing ACI research. To cater better exchange and comparisons between studies, our model proposes a starting point for recognizing and describing the key aspects of ACPI systems. In respect to ACPIs being repeated, yet not stereotypical activities, very little evidence on the duration or iteration of interaction is provided in earlier documentations of animal-computer play. We therefore call for research that defines the duration and repetition of possible playful interactions.

Many ACPIs are designed with the goal of strengthening the bond between human and non-human animals. To fully characterize interactions which involve a game between a human and an animal (such as Felino or Metazoa Ludens), the framework needs to be extended, incorporating the role of human and his interaction with both animal and device. Further research is needed to understand the ways in which humans and non-human animals use technology and games together and in parallel.

Finally, one single characteristic common to all introduced example studies challenges any straightforward application of Burghardt's criteria into recent ACPIs. Namely, the captive settings of the studied individuals provide both 'artificial' safety and departure from 'natural'

development from juveniles to adults. Instead, captive settings typically provide excess time unlike 'natural' environments in which play is a luxury performed at times of peace and full satisfaction (cf. Wirman 2013a). Domestic, zoo-bound animals as well as captive animals living in rescue centers do not perform typical development from juveniles to adults as seen in nature and generally attend play activities at all ages. It is therefore hard to define if an activity is a 'non-serious', simplified version of later adult activity. Comparisons between domestic animals and animals living in rescue centers were left outside of this preliminary study, but appear as an interesting area for further research. What can be drawn from our attempt to define ACPIs in this paper is the peculiarity of captive settings in general.

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