Digitally Complemented Zoomorphism: a Theoretical Foundation for Human-Animal Interaction Design

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ABSTRACT
From an interspecies perspective, we advocate for a theoretical foundation aimed at facilitating further research towards digitally mediated human-animal interaction. The proposed framework follows an approach we call '*digitally complemented zoomorphism*' and recognizes 'play' as a free and voluntary activity that is shared by both animals and humans. As a result, three initial design guidelines will emerge. Our work is pursued in order to provide animals with stimulations which stem from a closer understanding of their perceptions and are not solely designed around human subjectivity.

Author Keywords
Human-animal interaction; technology; play; design; user experience.

General Terms
Design; Theory; Human Factors.

INTRODUCTION
The values of Western culture are conducive to spending a considerable amount of resources on the development of technological artefacts which mediate the relationships between humans and animals[1]. The amount of physical products as well as software applications dedicated to human-animal interaction available on the market, such as remote human-animal interaction [4,11,17,23], and the growing amount of industry-sponsored applied research projects [18,19] are symptomatic of an increasing commercial interest in deepening the understanding of relationships between animals and humans as well as their technological mediators.

The research area for technically mediated human-animal interaction is still exploratory. However, the increased relevance of the relationships human beings establish with animals, as well as the importance of improving the animal welfare in society encouraged new research and fostered technical innovation. This is exemplified by research in agricultural fields [1,12,21] and domestic animal markets [14, 26].

This paper will propose a complementary theoretical approach to the design of physical products as well as software applications capable of providing a more compromising bodily and mental stimulation for the animals who share anthropic environments and social practices with humans. The user-analysis methodologies and design approach that will follow from the establishment of such a theoretical foundation can guide the practical design of artefacts that will more closely embrace the actual preferences and behaviour of animals. This shift towards an increasingly important role of the user in the design process has similarities with already established concepts like Participatory Design [22] and User-Centred Design [16]. However, the focus on non-human users requires techniques for the gathering and the understanding of animal feedback to inform and guide design decisions and research methodologies that are generally different from those passed down from the tradition of User-Centered Design. Their dissimilarity is in general introduced in order to avoid interpretations of preferences and behaviours that would solely be founded on human subjectivity. This paper will provide a preliminary theoretical foundation towards the understanding of what it means to design technology that has animals as its intended users.

[1] The term 'technological artefacts' is used as a reference to all mediators designed by human beings that interfere in human-animal interaction. The term is specifically employed in order to take an objective perspective on what animal scientist Ruth C. Newberry describes as vague notions that are used inconsistently throughout literature and might contain anthropomorphic notions, including terms like environment enrichment or toys [15].

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Within the structure of this paper, a review of the existing applied research in the area of digital technology intended for animal use will first and foremost demonstrate that there is currently no existing and guiding framework that can help researchers in developing a better understanding of their non-human users. We will then propose a '*zoomorphic*' approach in which the free and voluntary activity of '*play*' is understood as a form of interaction that is already naturally occurring in both animals and humans.

The three preliminary, general design guidelines that stem from this framework could be more exhaustively expressed as a '*digitally complemented zoomorphism*'. The descriptor '*digitally complemented*' indicates that a necessary portion of our embodied analysis of the human-animal relationship will not rely on human subjectivity, but will be performed digitally. The latter could consist of tracking and collecting metric and biometric data that quantify the animals' interaction with technical artefacts and changes of their bodily dimensions during specific technically-mediated activities.

The theoretical basis of this paper will finally be complemented with practical implementations that suggest how further research can be conducted according to the three suggested initial design guidelines The stark theoretical approach offered by this paper does not mean to suggest that research through praxis and/or design was unsuccessful in its entirety or should be avoided in principle. Our framework rather serves as a preliminary stage that proposes a foundation for understanding what it means to develop technology for animals and the design considerations that arise with this.

RELATED WORK

A reading of the recent, existing literature in the field reveals an understanding of human-animal interaction that, despite its fundamental, structuring role, is not yet openly discussed or justified. As a consequence, the existing works could be labelled – following Daniel Dennett's insights – as '*folk animal psychology*' [7], since their findings are possibly true, but unproven. The absence of a theoretical foundation led to two methodological issues:

1. First of all, the absence of a systematic approach resulted in the design of experiments, products and applications that are still tentative and do not work towards the structuring of a shared design methodology.

2. Secondly, the benefits of technologically mediated animal interaction are currently focused on the perception of animal needs, based on subjective human judgements and the human end of the animal-human relationship.

However, this anthropomorphism, the attribution of human characteristics to non-human entities [24], is the essential background against which human beings understand animals, their behaviour and their interaction with them.

Tentative research

The existing literature in the field of technical artefacts for human-animal interaction often includes the proposal of a concrete concept for a technical artefact. The proposed mediators are subsequently evaluated only by pet owners in the form of focus groups, interviews and/or prototype based experiments [17,18,19,27]. Even though these trial-and-error-based approaches might provide valuable insights on the human pole of the relationship in terms of expectations and preferences, the concept proposals face usability problems on the animal end such as the inability to reliably measure the physical wellbeing of the animal [19] and the creation of fully functional prototypes [18,27].

For example, Paldanius et al. proposed three different concepts as explorative studies aimed at gaining a better insight into the experiences and expectations of dog owners in order to inform the design of successful digital human-dog interaction technology [19]. This approach was revelatory of a fundamental methodological problem: the assumption that the analysis of the human engagement in the relationship will lead to practical design objectives and approaches which will improve the wellbeing of the dog. In another research example, a digital application intended for cats was examined [17]. Similar to the research mentioned above, the design was informed and based on human perceptions of animal preferences and enjoyment with the purpose of providing a game application for cats, without relying on or constructively proposing a design methodology or set of guidelines. Even though these research examples provide valuable exploratory research, it would be helpful, and we believe necessary, for the design of meaningful interaction to have a better understanding of the intended user.

Anthropomorphism

According to human-computer interaction researcher Clara Mancini the current design of existing technologies intended for animal use is fundamentally anthropomorphic [13]. A human focus is also detectable in existing research towards technological artefacts aimed at the mediation of the relationships between humans and animals [17,18,19,26,27]. In the mentioned articles, user studies performed on human participants are pursued and utilized to guide the design of mediating artefacts. This could logically be embraced as an appropriate component of a design methodology if the pet owners themselves were the intended end-users of the technology. The declared scope of the existing research and the technological concepts that were prototyped as a result, however, is that of engaging the pet as well as improving the wellbeing of the animal and the relationship with its owner.

Next to the digitally mediated human-animal interaction research mentioned in this section, the risk for anthropomorphism and a failed recognition of the animal needs and behaviour exists in research towards other (non-digital) mediators in human-animal interaction such as toys

and environment enrichment. According to animal scientist Ruth C. Newberry, concepts like 'animal welfare', 'stress', and 'environment enrichment' are vague notions and are used inconsistently in literature. Currently, no standardised methods or criteria allow the assessment of whether actual enrichment occurred [15].

Assessing the issues that affect current research oriented towards the development of technologies and products intended for animal interaction, Mancini observed that it might be helpful to start regarding animal-computer interaction as a discipline in its own right. She also suggested moving away from pursuing practical research and, instead, investing time and resources more constructively into working towards a systematic development of the field [13]. In a later article, Mancini et al. raise the same issues and propose to question what technologically-mediated human-animal interaction might mean for both the humans and the animals in terms of interpretational mechanisms and the way it affects the animal [14]. In order to make technological artefacts useful in providing meaningful and balanced interactions with animals, we agree with Mancini (et al.) that a more systematic research approach is preferable at this point.

THEORETICAL FOUNDATION

This paper proposes a theoretical framework with the purpose of structuring a methodological approach to the design of technological artefacts that have animals as their intended users. We suggest that a complementary, more examined, and less anthropomorphic understanding of what we are trying to accomplish with technological artefacts intended for human-animal interaction would be beneficial.

The Centric Animal

As a starting point for understanding what it means to design technology with animals as intended users we will introduce the fundamental differences between humans and animals according to Helmut Plessner's theory of positionality. This theory interprets the elementary dissimilarities between plants, animals, and human beings in terms of their spatial organization and independence from their environment. His original standpoint can be used, we believe, as a theoretical foundation to better understand the perceptual, cognitive and semiotic differences between humans and animals, differences that need to be taken into account when designing interaction for animals.

According to Plessner's theory, a plant has no awareness or consciousness of itself or its environment. Furthermore, a plant does not have a centre of experience and therefore cannot relate to its external boundaries [20].

Animals, on the other hand, have an experiential centre and a degree of self-awareness which is called a 'centric positionality'. This relation to their surroundings enables animals to make independent decisions, such as moving to a better location, or to an, for humans indefinable, extent interact with other beings. Thus, the availability of a centre makes the animal self-aware of its own body and experiences [20]. Figure 1 graphically explains this theory.

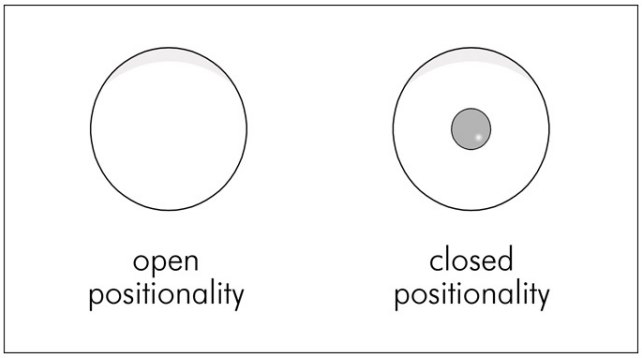

Figure 1: The first two positionalities of organic life according to Plessner in the visual interpretation of philosopher Jos De Mul [5]. The diagram on the left characterizes an 'open form': a form that has no autonomy in relation to its environment, as in the case of plants. The one on the right exemplifies a 'closed form': a type of positionality whose centre of experience allows an organism to develop awareness of its world as well as a degree of independence from it. The latter is the case of animals: animals that can take several decisions with regards to their behaviour in the world, for example in relation to moving, feeding, mating, playing, et cetera.

At last, the human being also has a 'centric positionality' but can, on top of that, form a cognitive relationship with its very experiential centre. Plessner describes this as an 'eccentric positionality'. As such, a human being is better capable of self-reflection and of making decisions which are more independent from its environment [20]. Figure 2 graphically explains the complete theory.

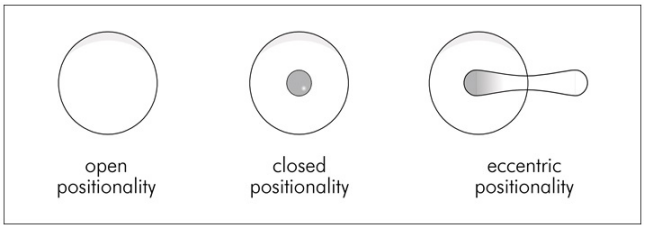

Figure 2: The three possible 'stages of the organic' according to the theory of positionality proposed by Plessner in 1928 in the visual interpretation of De Mul [5]. The 'eccentric positionality', characteristic of human beings, shows two coexisting and connected nuclei: one within the body (the bodily experiential centre accountable for inner experiences) and the other outside of it (allowing for the possibility of self-reflection and for interpreting one's own body as an object).

Even though humans and animals perceive their environment in a different manner, an activity in which humans and animals share concepts of understanding and responses to signs, cues, and behaviour includes physical

'*play*', a recognizable and voluntary activity that is observed in many mammals. Such a quality makes it a suitable context for further research with the purpose of finding a more compromising and animal-inclusive approach for the design of technological artefacts aimed at mediating human-animal interaction.

Physical Play

In his 1938 book, historian Johan Huizinga proposed a vision stating that the fact that animals, similarly to human beings, naturally engage in play demonstrates that they must be more than merely mechanical systems [10]. In other words, if animals are somehow aware of the fact that they are playing, which is a deliberate activity and includes a degree of separation from reality, they must be more than merely instinctual beings univocally engaged with the practicalities of their surroundings.

Animal scientist Marc Bekoff and philosopher Colin Allen explained that play is a tractable, evolved behavioural phenotype that lends itself to further research, and social play (including interaction with another living creature) occurs in a wide range of species and involves issues of communication, meaning, role-playing and cooperation. Furthermore, in a way that is not dissimilar from Huizinga, they raise questions on the availability of self-conception that, to some extent, seems to be forthcoming in animals during play [2].

Bekoff and Allen additionally propose a more encompassing vision on animal cognition, observing that an animal may have specific cognitive abilities related to particular states or intentions of other creatures, without having the general ability to reason or form specific deliberate content as a response to the interaction [2]. In other words, an event such as play may involve behaviour that resembles eccentric activities, even though neither participant has a general conception of this behaviour.

In this matter, it becomes clear that centric animals seem to experience play as something different than eccentric human beings, because their experiential structure is organized in a different way. Centric animals might not have the full ability for self-reflection and their experience and perception of the environment is different from ours. However, when focusing on play in animals that human beings share certain characteristics with, a mutual understanding and response to signs, cues, and behaviour emerges. This can not only be observed in same-species interaction in play, where the animals react on each other's signals and communicate the intention to play, but is also exemplified in the way humans play with domestic animals such as dogs. Both the dog and its owner are, for example, able to communicate specific signals that invite the other being to play, understand the limits of the play session, and understand when the play has ended. This bodily conception (which will be described as 'going-along' later in this paper) of each other can be explained, according to a more gradient understanding of Plessner's theory of positionality, by the fact that – during play - animals and humans have analogously eccentric positionalities.

The similarity in the structuring of human and animal cognitive activity during play indicates that play itself can form a specifically suitable context wherein to start developing a theory about inter-species understanding. In this respect, this study currently has a general focus on 'higher' animal species that have relatively advanced abilities, share certain characteristics in life with human beings, and are suitable for human-animal interaction (including for example non-human primates, higher domestic animals such as cats and dogs, and other placental mammals with cognitive abilities that are familiar to those of human beings).

Furthermore play, as an activity that is characteristically voluntary and free, naturally provides a shared context in which the animal is not forced or artificially involved in the interaction.

A clear and workable definition of the term 'play' in the present work is necessary in order to clarify how our theoretical framework can be used to analyse the playful interspecies interaction with technological artefacts. According to Burghardt, there are innumerable ways of characterizing and defining play. However, he argues that many of these definitions provide nothing more than a list of factors involved in play, while what he considers necessary is an approach that allows systematic analysis in order to separate 'play' from other behaviours with which it may be confused [3]. Burghardt therefore provides a definition of animal play according to five criteria, following an ethological approach:

1. The behaviour is not fully functional in the form or context in which it is expressed (not contributing to current survival);
2. The behaviour is spontaneous, voluntary, intentional, pleasurable, rewarding, reinforcing, or 'done for its own sake' (at least only one of the concepts listed above needs to apply in order for play to be recognized);
3. The behaviour differs from serious performance because it is incomplete, exaggerated, awkward, precocious, or contains modified behavioural patterns;
4. The behaviour is expressed repeatedly during at least some parts of an animal's life span;
5. The behaviour is performed when the animal is in a benign, relaxed or low-stress situation [3].

Although some of the concepts proposed in this set of criteria are inevitably bound to the way humans understand animal behaviour, this general definition of play is set up in such a way that the availability of all five criteria helps us distinguish playful behaviour from non-playful behaviour.

DIGITALLY COMPLEMENTED ZOOMORPHISM

The understanding of positionality in animals in physical play lays the foundation for a theoretical approach and a more aware and compromising form of anthropomorphism. This zoomorphic approach relocates the focus from the human perspective towards a better understanding of the perception and preferences of the animal. Besides its intrinsic theoretical value, in our intentions such a perspective is supposed to open the way for further research towards the design of technological artefacts that mediate the relationships between humans and animals. We propose the term '*digitally complemented zoomorphism*' as an approach that stems from this foundation and we provide three preliminary, general design guidelines:

1. The use of external stimuli in the form of technological artefacts;

2. The analysis of animal behaviour through '*going along*' in a common embodied praxis (such as play);

3. The digital tracking and collation of metric and biometric data concerning the animal experience.

1. Technological artefacts as external stimuli

This paper proposes that the natural curiosity of animals and their explorative behaviour could be used to stimulate their engagement with interactive technological artefacts in a research setting.

According to Burghardt, most animals show explorative and investigating behaviour when new objects appear in their environment. These activities are linked to play and can show overlapping types of behaviour (such as playful body signals), but are different in context, bodily dimensions, and function [3]. In this case, the most useful insight is that exploratory behaviour and curiosity are often visible before play, and thus effectively promote playful behaviour in the animal [3]. In this matter, we can ensure that the interaction is offered as a voluntarily activity.

In combination with the focus on actual play, this means that the technological artefacts we design for playful human-animal interaction have a function in facilitating environmental stimuli that motivate the animal to play and engage in voluntary human-animal interaction.

2. Going-Along: a Mutual Understanding

As already mentioned, play facilitates a mutual understanding due to the shared interaction and response to bodily cues. According to philosopher Jos De Mul, common traits in the way bodily signals are produced and interpreted allow specific species to understand other species to a certain degree. In particular, he argues that the dimensions that constitute the human world enable us not only to meaningfully relate to other human beings, but up to a certain degree to understand animal life as well [6]. In other words, a closer insight into the intentions of an animal could be achieved by '*going-along*' in a common embodied praxis such as play.

The objective of this shared activity with the animal is not attributed *a priori*, but unfolds itself intuitively in the course of the interaction. An example includes the elementary understanding of the intentions of a dog while playing with a human being.

In the work of Donna Haraway it is emphasized how we can better understand other animals and the relationships we have with them by engaging with their material semiotics, even if they are not fully accessible [9]. On this basis, Mancini et al. recently published an article in which they proposed the exchange of indexical semiotics through which humans and dogs could *coevolve* [14]. This article describes how one of the three kinds of communication signs ('*symbols'*, '*icons'*, and '*indices'*) is specifically suitable for trans-species interaction. Where '*symbols*' and '*icons*' are merely abstract signs and require linguistic abilities, '*indices*' are instead directly and physically grounded in a bodily relationship with the world and other beings and thus neither preclude nor require shared mental abilities [14].

In other words, if we are able to interpret a dog's semiotic processes on the level of understanding their indexical signs, we can connect meaning to them in the context of human-animal interaction.

The work of Mancini et al. provides a first structured approach regarding research in the area of digitally mediated human-animal interaction. However, this work continues to rely on a subjective understanding of the animal (since it focuses solely on human interpretations), and does not stem from an articulated theoretical framework. Instead, our work proposes the possibility to structure a more objective framework for human-animal interaction which initially focuses on the interspecies understanding that naturally occurs in the activity of play and is complemented by the use of interaction data and bodily measurements during the interaction itself. This will be proposed in the form of metric and biometric observations in the next section of this text.

This new approach could provide a more thorough, interactive and balanced comprehension of the animal, its behaviour and its intentions.

3. Metric and Biometric Research

Despite the understanding of the animal through an embodied and shared interaction and the avoidance of superficial forms of anthropomorphism, the zoomorphic approach proposed in this study still stems from a rather subjective human perception of animal behaviour. In order to complement this human subjectivity, metric and biometric research could offer valuable insights. This includes the digital tracking and collation of metric and biometric data to uncover the interaction with the artefact

and changes in the animals' bodily dimensions and/or movements. In other words, by measuring psychophysiological changes in the body of the animal with a higher degree of objectivity (monitoring physical dimensions such as heart rate, respiration, or body temperature, or by digitally measuring changes in the movement patterns of the animal such as pacing, position, or types of interaction with technological artefacts), the reaction of the animal to certain stimuli or experiences can be understood and quantified in a more systematic manner. Furthermore we can use metrics, for example through the logging data of the technical artefact, to define quantitative patterns in the user interaction that can be used to improve the artefact.

According to Burghardt, biometric measurements of pleasurable states during play have not yet been carried out, but, for example, heart rate measurement in horses when they were confronted with novel stimulus showed that their heart rate was reduced, which is often found when the animal's attention is focused. Therefore, studying heart rate changes during free play sessions might be useful in assessing the experience of horses during play [3].

However, in order to obtain valuable data the measurement of psychophysiological dimensions needs to be accurate and precise. According to Goodenough et al. biometric data is subject to high levels of variability [8]. In addition, the application of sensors and electrodes on animals causes difficulties in both receiving accurate measurements (for example due to sudden animal movements) and in that it interferes with the normal behaviour of the animal (for example when the animal tries to remove the sensors or is restricted in its movements).

Therefore, in order to avoid the limitations of measuring valuable psychophysiological data, we suggest to start with a focus on the digital tracking and analysis of external biometric measurements through computation of videotaped observations. The tracking of data through external sensors can provide more thorough insights in the interaction with both the technological artefact and the human being involved in it without having to apply sensors on the animal's body.

We could, for example, digitally monitor the animal's movement patterns during the interaction with the use of multiple video cameras and/or GPS tracking. Next to this, the human being involved in the interaction could wear a head-camera in order to define when and how many times eye-contact with the animal is established. Moreover, the technological artefact that is tested in the experiment could contain for example pressure, acceleration, or touch sensors in order to measure how the playful interaction with a certain artefact takes place.

On this basis, a combined interpretation of the interaction with the animals and technological artefacts designed by human beings, reports by the humans involved in the activity, the use of metric data and the tracking of the animals' biometric dimensions or behaviours during the interaction is likely to provide a solid, balanced and sustainable understanding of the involvement and the level of enjoyment of both poles of the relationship. This design approach can complement further research in the area of technologically mediated human-animal interaction.

PRACTICAL IMPLEMENTATIONS

Following from the theoretical framework and the design approach presented in this paper, this paragraph provides initial suggestions that can be used for further research towards the design of technical mediators as well as conducting user tests with animals. These suggestions focus on the design of technological artefacts that facilitate play, invite the user to interact with the artefact on a voluntary basis and carefully combine both quantifiable data as well as subjective human observations before continuing in making design decisions.

Since this paper provides initial design guidelines for human-animal interaction in its general understanding, there are no specific characteristics mentioned that apply to specific animal species. However, since each species shows different playful behaviours, the research towards the design of technological artefacts requires a difference in approach in designing meaningful interaction for each individual species. Therefore the first step that is suggested consist out of the gathering of existing research, observations, and expert knowledge on the specific animal species that will be considered the final user of the design process. With a focus on play, this research includes an understanding of the playful signals, intrinsic motivational patterns, and other behaviour performed by the animal during play.

Before user experience analysis or prototype tests can be conducted, the ethical principles of doing research experiments with animals need to be considered. Ethical guidelines that deal with the short- and long-term effects of the developed technology and related interventions on animal welfare are for example reviewed and discussed by Väätäjä and Pesonen [25]. These can serve as an initial outline for animal-user studies.

During the design phase it is up to the designer to balance the human experience and the perception of the animal experience in order to design meaningful interaction for both the human and the animal. Since there is always a human element involved in the design of technology, a certain degree of anthropomorphism is always present and unavoidable. However, the more balanced zoomorphic approach presented in this paper complements this phase with a combined interpretation of both quantifiable and subjective research data of the user tests.

In order to successfully interpret data from testing sessions, the user studies and prototype tests need to be carried out in collaboration with experts that have experience in interpreting animal behaviour and could provide more insights on the interaction that can be observed. Furthermore, the technological artefacts need to serve as external stimuli with which the animal can interact on a voluntary basis. The further outline of follow up research in the form of, for example, new user studies, a/b testing, or preference studies is logically dependent on the outcomes of the user tests, the application of the presented methodologies, and the focus of the research.

The next step in this research is to further test and validate this approach with the use of practical experiments and finally to design technological artefacts that are actually capable of providing animals with both playful and meaningful interaction.

CONCLUSION

Our research argues that the existing applied studies aimed at the creation of technological artefacts for human-animal interaction are often exploratory, have a marked human focus, and draw conclusions based on superficial anthropomorphic statements. This approach resulted in the design of methodologies that are tentative, and do not respond to or accommodate the current needs and behaviour of the animal.

The understanding of positionality in animals in physical play constructs a novel theoretical framework that provides a basis for further research in the field of animal-oriented user studies and human-animal interaction design that is based on a more compromising and balanced form of anthropomorphism. In relation to this we propose the term '*digitally complemented zoomorphism*' and provide three initial, general design guidelines:

1. The use of external stimuli in the form of technological artefacts to motivate the animal to play and engage in human-animal interaction in a research setting and on a voluntary basis.

2. The pursuing of a closer understanding of the animal, its behaviour and its intentions by 'going-along' in the embodied praxis of play with animals we share certain characteristics with in life.

3. The complementation of the above with the digital tracking and collation of metric and biometric data in which we receive more objective insights in the interaction with the artefact and the changes of the animals' bodily dimensions during specific technically-mediated activities can be monitored and understood.

We believe this approach will lead to the realization of technical mediators that will more closely align to the preferences and behaviour of the animals, and are not solely designed around human subjectivity.

The limitations in measuring valuable and accurate biometric data in animals could be overcome by concentrating on the use of external biometric measurements. Such data will provide the researchers with a more objective and quantifiable complementation of the insights in the behaviour of animals in addition to the more subjective bodily understanding of the interaction through 'going along' in the shared activity of play.

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REFERENCES

1. Alfrink, K., Van Peer, I., Lagerweij, H., Driessen, C., and Bracke, M. Playing with Pigs. Retrieved September 2, 2012 from http://www.playingwithpigs.nl

2. Bekoff, M., and Allen, C. 1997. *Intentional communication and social play: how and why animals negotiate and agree to play.* In Bekoff, M., and Byers, J. A. 1998. *Animal Play.* Cambridge: Cambridge University Press.

3. Burghardt, G. M. 2006. *The genesis of animal play. Testing the limits.* London: MIT Press.

4. Camstreams for Pets. Retrieved September 10, 2012 from http://www.camstreams.com/petanimalwebcams.asp

5. De Mul, J. 2010. *Cyberspace Odyssey: Towards a Virtual Ontology and Anthropology*. Cambridge: Cambridge Scholars Publishing.

6. De Mul, J. 2013. Understanding nature. Dilthey, Plessner and biohermeneutics. In: G. D'Anna, H. Johach, and E. S. Nelson (eds.), *Dilthey, Anthropologie, und Geschichte*. Würzburg: Königshausen & Neumann, Spring 2013. Preprint available at http://www.demul.nl/en/publications/select-publication-catagory/book-chapters/item/1523-understanding-nature-dilthey,-plessner-and-biohermeneutics

7. Dennett, D. C. Intentional systems. *Journal of Philosophy, LXVIII 4* (1971), 87-106.

8. Goodenough, A. E., Smith, A. L., Stubbs, H., Williams, R., and Hart, A. G. Observer variability in measuring animal biometrics and fluctuating asymmetry when using digital analysis of photographs. *Ann. Zool. Fennici 49* (2012), 81-92.

9. Haraway, D. 2008. *When species meet.* Minneapolis: University of Minnesota Press.

10. Huizinga, J. 1955. *Homo ludens; a study of the play-element in culture*. Boston: Beacon Press.

11. ISeePet. Retrieved September 10, 2012 from http://www.ehomeupgrade.com/2004/04/24/iseepet-webcamfeeder/

12. Lee, S. P., Cheok, A. D., and James, T. K. S. A. Mobile pet wearable computer and mixed reality system for human-poultry interaction through the internet. *Personal and Ubiquitous Computing 10* (2006), 301-317.

13. Mancini, C. Animal-computer interaction: A manifesto. *ACM Interactions 18* (2011), 69-73.

14. Mancini, C., Van Der Linden, J., Bryan, J., and Stuart, A. Exploring interspecies sensemaking: Dog tracking semiotics and multispecies ethnography. *Proceedings ACM Ubicomp* (2012), 143-152.

15. Newberry, R. C. Environmental enrichment: Increasing the biological relevance of captive environments. *Applied Animal Behaviour Science 44* (1995), 229-243.

16. Norman, D. A., and Drapper, S. W. 1986. *User centered system design: New perspectives on human-computer interaction*. Hillsdale: Lawrence Erlbaum.

17. Noz, F and An, J. Cat cat revolution: An interspecies gaming experience. *Proc. Of the 29th International Conference, Human Factors in Computing Systems* (2011), 2661-2664.

18. Paasovaara, S., Paldanius, M., Saarinen, P., Häkkilä, J., and Väänänen-Vainio-Mattila, K. The secret life of my dog – design and evaluation of paw tracker concept. *Proc. Of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services* (2011), 231-240.

19. Paldanius, M., Kärkkäinen, T., Väänänen-Vainio-Mattila, K., Juhlin, O., and Häkkilä, J. Communication technology for human-dog interaction: Exploration of dog owners' experiences and expectations. *Proc. Of the 29th International Conference, Human Factors in Computing Systems* (2011), 2641-2650.

20. Plessner, H. 2006 (1928). *I gradi dell'organico e l'uomo. Introduzione all'antropologia filosofica*. Torino (Italy): Bollati Boringhieri.

21. Rossing, W., Hogewerf, P. H., Ipema, A. H., Ketelaar-De Lauwere, C. C., and De Koning, C. J. A. M. Robotic milking in dairy farming. *NJAS Wageningen Journal of Life Sciences 45* (1997), 15-31.

22. Schuler, D., and Namioka, A. 1993. (Eds). *Participatory design: Principles and practices.* Hillsdale: Lawrence Erlbaum.

23. Tagg The Pet Tracker. Retrieved September 10, 2012 from http://www.pettracker.com/

24. Tyler, T., and Rossini, M. 2009. *Animal encounters*. Leiden: Koninklijke Brill NV.

25. Väätäjä, H., Pesonen, E. K. Ethical issues and guidelines when conducting HCI studies with animals. *CHI '13 Extended Abstracts on Human Factors in Computing Systems* (2013), 2159-2168.

26. Weilenmann, A., and Juhlin, O. Understanding people and animals: The use of a positioning system in ordinary human canine interaction. *Proc. Of the 29th International Conference, Human Factors in Computing Systems* (2011), 2631-2640.

27. Wingrave, C. A., Rose, J., Langston, T., and LaViola, J.J. Early explorations of CAT: Canine amusement and training. *Proc. Of the 28th of the International Conference Extended Abstracts on Human Factors in Computing Systems* (2010), 2661-2670.