Animal-Computer Interaction (ACI): changing perspective on HCI, participation and sustainability

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Animal-Computer Interaction (ACI): Changing Perspective on HCI, Participation and Sustainability

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Abstract
In the spirit of this year's conference theme 'changing perspectives', this paper invites the CHI community to glance at interaction design through the lense of Animal-Computer Interaction (ACI). In particular, I argue that such a perspective could have at least three benefits: strengthening HCI as a discipline; broadening participation in Interaction Design; and supporting CHI's commitment to sustainability. I make the case that, far from being a niche research area, ACI is directly relevant to and even encompasses HCI. Thus ACI research firmly belongs at CHI.

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H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

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Design, Theory

Introduction

The number of HCI researchers interested in the interaction between animals and computing technology is gradually increasing. However, to date this remains a fringe trend at the margins of the CHI community, where such research interests are still deemed to belong in a niche area [25]. In other venues, contributions focusing on animal-computer interfaces start appearing at the turn of the century [27] and possibly earlier, yet at CHI there is nothing until McGrath's short review of species-appropriate computer-mediated interactions in 2009 [18]. Between then and 2012, the conference program features a few more contributions on computer-mediated human-animal interaction [33,20,21,32,5]. These narratives begin to look at humans and computing interactions within multispecies ecologies but maintain a decidedly anthropocentric focus. Indeed, one might expect that interaction design research with a nonhuman focus would not be submitted at CHI; or, if it was submitted, that such work would be filtered out during the reviewing process, and its submission would thus be discouraged. Of course, this would hardly be surprising: after all CHI is a conference on human-computer interaction. Nevertheless, I am concerned that this community might be missing out on work which could be both relevant and beneficial to its research interests, and which could even function as a benchmark against which actual or potential advances in certain areas of HCI could be assessed. Thus the main question is whether interaction design research which does not primarily focus on humans is relevant to HCI and, if so, in what way.

Perhaps one issue is that so far interaction design research on nonhuman computing systems and interfaces has tended to focus more on developing or analyzing novel animal technology than on establishing systematic theoretical and methodological connections between animal-computer interaction as a discipline, on the one hand, and the HCI tradition and agenda, on the other hand. Here I try to discuss those connections and make the case that Animal-Computer Interaction (ACI) as a discipline [15] is directly relevant to and even encompasses HCI, and therefore ACI research firmly belongs at CHI. Firstly, I attempt a more or less chronological (representative rather than exhaustive) overview of the theoretical and methodological developments in ACI. Secondly, I discuss how ACI research has the potential to yield at least three benefits: strengthening HCI as a discipline; broadening participation in Interaction Design; and supporting CHI's commitment to sustainability.

The emergence of ACI

I suggest distinguishing between animal technology and technology informed by animal-computer interaction. By animal technology I mean any technology intended for animals, whose development is not necessarily led by user-centered design principles. While such technology may have to make concessions to the animal's physiological and psychological characteristics, there is an underlying expectation that the animal will adapt to the technology rather than the other way around. Such technology has been around for ages [15] and might be found, for example, in research laboratories, modern farms or even in the field settings of conservation studies. On the other hand, by Animal-Computer Interaction I mean the explicit and systematic application of design principles that place the animal at the center of an iterative development process as a legitimate user and design contributor.

Such an approach to the development of technology intended for animals is much more recent.

The first to deliberately and systematically apply HCI principles to the design of animal interfaces appears to be Resner [24]. Rover@Home, his remote human-dog interaction system allowing humans to teach their dogs new tasks during computer-supported clicker-training sessions, is sometimes cited in the literature as a pioneering example of human-animal interface. From an ACI perspective, however, more significant is Resner's proposal of an early theoretical framework for animal-computer interactions, based on the generalization of User-Centered Design (UCD) [19]. With consideration for canine physiological (e.g. sensorial) and psychological (e.g. cognitive) characteristics, Resner rigorously applies the analytical concepts of task domains, affordances, cognitive modeling and direct manipulation to the design of his system. He also develops the concept of asymmetrical human-canine interfaces, where the interaction is enabled at each end in a species-specific way; and proposes the use of species-specific forms of ritualized interaction (e.g. clicker training with dogs or string pulling with cats) as a model for computer-mediated human-animal interactions. It is the author's declared intent to include animals in HCI, for which he argues that methodological research approaches such as contextual enquiry are preferable to laboratory studies, as they enable researchers to understand the full complexity of the animal's natural settings and characteristics. However, he discounts the use of co-operative approaches, on the grounds that, since animals cannot express themselves verbally, they are unable to participate in the design process. Thus animals don't qualify as research participants (or even users: indeed the author never refers to them as such), but remain subjects in a design process which is mindful of their known characteristics.

However, a few years later Demi Mankoff, a Labrador with a witty sense of humor, and her human co-authors [17] beg to differ. Their Pawsabilities Pack Awareness Watch System for remote human-dog interaction is developed, as the authors have it, through a "*pawticipatory*" design process which involves canine users from the start. The authors even seek to afford the canine the possibility to initiate the remote interaction herself through the use of ambient sensors (in her bed) to infer her psychological states (boredom) from her natural behavior (lying down). Amid endless jokes, the (human) authors manage to highlight a number of serious issues faced by researchers wishing to design user-centered technology for animals: the need to think from the animal user's 'viewpoint', the methodological inadequacy of most HCI frameworks and techniques, the necessity to closely refer to animal physiology and natural behavior to inform requirements, and the challenge of conducting controlled or at least reliable evaluations from the animals' perspective.

Some of these issues are elegantly (and shall we say more rigorously) addressed by Lee *et al.* [14] when developing their haptic wearable human-poultry interface for remote tactile interaction. The authors do not make explicit reference to HCI principles, or animal physiology and psychology, when designing the poultry interface; and wearability only receives a passing mention, and only in relation to the vest's weight. Nevertheless, as well as the experience of the human users, they do attempt to rigorously evaluate also the experience of the chickens, using a laboratory technique developed within animal welfare science [10]: during a four-week controlled study they allow their research subjects (two chickens) to choose where to spend time between two identical cages, in only one of which the chickens would be picked up to have the haptic jackets put on. To measure the chickens' motivation the researchers use weighted push doors at the entrance of the cage. In so doing, they demonstrate that a rigorous approach to the evaluation of computing interfaces from (so to speak) the perspective of the animal user is indeed viable.

A similar approach is taken later on by Cheok *et al.* [3] in the evaluation of their Metazoa Ludens, a mixed-reality human-hamster play and exercise system for remote interaction. Firstly, the authors ground their design of the animal interface in observations about species-specific behavior (hamsters won't chase food because they are not predators, but they will chase a moving tunnel because they like to burrow). Then, they carry out a four-week controlled study to evaluate the participating hamsters' motivation to play, by allowing them to engage with the game or leave the gaming area when a whistle signals the beginning of a play session. Moreover, the authors rigorously evaluate the benefits of the system to the hamsters' health by carrying out a six-week controlled study which entails the application of a veterinary health assessment framework [31], a strict dieting regime and a standardized schedule of regular play and exercise sessions. As a result of their research, the authors also propose heuristics for the design of human-animal interaction systems from an animal perspective, considering safety and comfort, ease of use, degrees of interactivity and choice, and enjoyment afforded by the system. Although these heuristics do not explicitly relate to HCI principles, they seem to map rather straightforwardly onto familiar usability and experience interaction design goals [26].

On another front, work recently presented at CHI seems to take a more ethnographic approach to the design and evaluation of computer-mediated human-animal interactions. Wingrave *et al.* [33] and Noz and An [20]'s systems for co-located playful interaction (both designed based on the same ritualized pattern of predatory chase) are informed by careful consideration of species-specific interaction requirements, refined over multiple iterations. In this work, both animals (respectively dogs and cats) and humans seem to be regarded as full-fledged research participants and users whose needs seem to equally motivate the technological intervention in question. Dealing with the human-animal interaction as a partnership and, in the case of Noz and An, in-the-wild allows the researchers to account for the richness of contextualized dynamics [20] and even identify articulated design guidelines for future iterations of the systems [33].

Within this kind of qualitative research, findings largely (albeit not solely) derive from the subjective input of human participants as well as the subjective interpretation of the researcher. This makes evaluating technological interventions from an animal perspective particularly problematic, as it raises the issue of intersubjectivity (i.e. the possibility of shared mental states) between humans (both participants and researchers) and animals. Briefly mentioned by Noz and An, this issue is explored in depth by Weilenmann and Juhlin [32] in their study of canine tracking practices during hunting. Drawing from Goode's work on ethnomethodology [6], the authors propose an ethnomethodological approach to the analysis of computer-mediated human-animal interactions, focusing on manifest interaction in context. Instead of assuming or discounting possible shared mental states between actors (human and canine participants), they delegate that decision to the actors themselves (the human participants), who appear to attribute mental states to their counterparts (the canine participants) on the basis of their manifest actions (their behavior) contextualized within a shared practice (the hunt).

Along the same line of enquiry, Mancini *et al.* [16] note that, for designing and evaluating animal-computer interactions as well as computer-mediated human-animal interactions, ethnomethodology may not go far enough. They suggest that, hard as it might be, researchers should seek to engage with the sensemaking mechanisms and processes that might be at play when animals interact with technology, or with humans via the mediation of technology, in order to understand how animals might make sense of those interactions. Thus in their study of canine tracking practices in the domestic context, drawing from Kohn's semiotic approach to multispecies ethnography [12], the authors propose an interspecies semiotic framework based on indexicality. This in turn entails analyzing the contextualized connections that an animal might establish between phenomena (e.g. a design feature and an event) in order to make sense of them. Such an approach, the authors argue, could integrate the accounts of human participants, typical of ethnographic enquiry, with the expert accounts of animal behavioral researchers found in the literature. I suggest that it could also integrate the ethnographer's contextualized observations with the findings of controlled experiments such as those carried out by Lee *et al.* [14] and Cheok *et al.* [3].

The work described so far, and related work in domestic and other settings (e.g. [30]), is mostly concerned with computer-mediated human-animal interactions. However, beyond human-animal interactions, the most challenging research questions and novel contributions emerging from these investigations are to do with the challenge of designing and evaluating interactive technology for very different user groups, that is user groups belonging to multiple species. Mancini [15] proposes that these diverse research questions and contributions pertain to the wider discipline of Animal-Computer Interaction (ACI), whose aims - analogously to HCI - would include:

- studying the interaction between animals and technology in naturalistic settings (e.g. use of voluntary robotic milking systems in farms, operant chambers in research laboratories, interactive toys in homes)
- developing user-centered technology that can a) improve animals' lives by supporting the fulfillment of their needs (e.g. healthy feeding systems for pets), b) support animals in the tasks humans ask of them (e.g. domestic interfaces for service dogs), c) foster interspecies relationships (e.g. human-animal interfaces for remote interaction)
- informing a user-centered approach to the design of technology intended for animal use, by systematically exploring, adapting and evaluating theoretical and methodological frameworks and protocols derived from both HCI and animal science.

But how is such a research agenda relevant to HCI research interests and to the CHI community?

Thinking outside the (human) box: ACI for enriching HCI

Resner [24] grounded his generalization of UCD [19] in the assumption that humans are also animals, in which case human-computer interactions would actually constitute a special type of animal-computer interactions. Thus, principles developed to design the former could also be used, at least at some level of abstraction, to design the latter. In return, the process of designing animal-computer interactions could benefit HCI, for example, by showing to what extent different principles might generalize.

While such a perspective may appear unorthodox to some HCI researchers, it is of course not new to most biological scientists, who have been studying humans as a part of a biological continuum for many decades. For example, disciplines such as evolutionary and comparative psychology seek to better understand human cognition and emotions by comparison to those of other species. There is no reason why computer interactions couldn't likewise be studied comparatively. In fact, the use of animal computer interfaces in cognitive research is becoming increasingly popular, particularly with the development of touchscreen input devices. For example, personal tablets and fixed screen interfaces [28] are routinely used by the residents of Savage-Rumbaugh's Bonobo Hope Great Ape Trust Sanctuary, within its world-famous research program on language acquisition by nonhuman species. It is not implausible that researching the optimal interface design for the apes' tablets might yield insights for improving interfaces to, for example, help pre-verbal or dyslexic children learn language. Resner [24] himself emphasized the possibility that HCI could benefit from nonhuman applications, for one thing, because interfaces developed for animals could turn out to be useful for particular human user groups too. For example, he proposed that, thanks to the principles of operant conditioning underpinning its canine interface, Rover@Home could be used by remotely located parents to teach pre-verbal children, otherwise unable to engage in remote interaction, labels such as shapes or colors. In his review of species-appropriate computer mediated interaction, McGrath [18] also pointed out how designing for other species challenges designers to understand the basic nature of interaction and prompts them to experiment with novel interfaces thus propelling interaction design forward.

However, beyond novel designs or specific technological solutions, it is at the theoretical and methodological level that ACI can enrich HCI as a science while pushing its boundaries. We have seen how ACI researchers are prompted to identify new, non-linguistic ways of involving animals in the design process, evaluating and studying the effects of their technological interventions, both in a quantitative and qualitative way. Just as HCI principles could be applied to the design of animal interfaces, so novel methods applied by ACI researchers could be applied to the design of human interfaces. For example, the evaluation method used by Lee *et al.* [14] to measure the chickens' motivation in experiencing the haptic jacket could be used by HCI researchers to measure humans' preferences for an interface that might be rendered harder to access but is hypothetically more enjoyable to use. For another example, the indexical semiotic approach proposed by Mancini *et al.* [16] to analyze canine sensemaking processes could be used to perhaps analyze human subconscious sensemaking processes within technologically mediated contexts. As scientists continue to debate on the nature of subjective experience in (human and nonhuman) animals [29], research methods which bypass the issue of consciousness without trivializing interaction have a role to play both in ACI and HCI.

Broadening participation: ACI for multispecies communities

Whatever the nature of our interactional experience, multispecies ethnography [11] has drawn attention to the complex, intimate connections and interdependencies which humans entertain with other species. Haraway [8] for one delineated endless processes of coevolution, of *becoming-with*, which characterize the relationships between living organisms defining who we are. Indeed, evolutionary biologists have found, for example, how instrumental our original and ongoing association with wolves has been to human evolution, without which *homo sapiens* would not have come to exist [7].

These days, *homo sapiens* is busy building around itself a world of ubiquitous computing. Embedded in the fabric of our cities, workplaces, homes, vehicles, clothes and even bodies, computing systems allow us to relate to the world around us, one another and even ourselves in unprecedented ways. However, if we allow anthropocentric technology to drive a wedge between us and those who made us who we are, we will not just lose them, we will lose ourselves too. Emerging research into human-animal computer-mediated interaction systems clearly shows that many humans don't want to inhabit ubiquitous computing worlds that their nonhuman companions cannot participate in. Thus these multispecies communities need to be designed for, or rather they need to be *designed-with*. Just as HCI aims to support human ecologies, so does ACI aim to support multispecies ecologies.

However, it is not just those involved in human-nonhuman interactions that could use ACI's support. Across the world, billions of animals engage in computer interactions in farms, in research laboratories or in open fields on a daily basis [15]. These animals potentially constitute an immense user base that interaction designers are yet to properly engage with. Not only could engaging with that user base improve the living conditions of billions of nonhuman individuals, it would also improve the processes in which those individuals are involved. In turn, addressing the challenges encountered during the process of broadening participation in computer interactions to include nonhuman users, ACI has the potential to indirectly benefit particular groups of human users too. For example, as mentioned above, interfaces designed for certain groups of nonhuman users could also be accessible to human users (e.g. little children or even babies, adults experiencing cognitive limitations or physical impairments) whose physiological and psychological characteristics might present relevant correspondences to those of the original target user.

Although humans have proportionally the largest prefrontal cortex around, most of the processes that shape our interactions and social dynamics do not unfold in there [23]. Affective neuroscience tells us how it is in our reptilian and mammalian brains, which we share with our evolutionary ancestors, rather than in our cortex, that our emotions mostly play out [22]. Designing affective interactions for users with smaller cortexes could deliver better affective computing, which is accessible to both human and nonhuman animals. In turn, this could enable us to better understand and relate to other species and work more effectively towards the creation of more inclusive societies.

Constructing sustainability: ACI for systemic design

Creating more inclusive societies is not only ethically desirable, it is necessary if we are to secure the survival of our own species. Arguably global warming is testimony to the fact that continuing to cater for human interests at the detriment of other living beings cannot sustain human life in the long run. Biologists have long been telling us how human activity is dangerously threatening the very biodiversity which sustains human life [4]. Sustainability appears to have become a significant concern within HCI and the CHI community itself. However, Brynjarsdóttir *et al.* [2] recently discussed the limitations of current persuasive approaches noting how these disregard the systemic nature of the problem, failing to include the actors in the design of solutions within collective practices. Moreover, so far most of the work in this area has focused on the consumption of resources such as water and electricity, whether within domestic or industrial settings, with almost complete disregard for the production and consumption of resources such as food.

With nearly 65 billion farm animals slaughtered in the global food industry yearly, in 2006 FAO declared the animal agriculture sector a major threat to the environment, responsible for 18% of all anthropogenic greenhouse-gas (GHG) emissions. More recently, Koneswaran and Nierenberg [13] found that animal agriculture accounts for 9% of CO_2 (1 GWP: Global Warming Potential coefficient), 35-40% of CH_4 (23 GWP) and 65% of N_2O (296 GWP) of anthropogenic GHG emissions, as well as being a significant contributor to environmental degradation (e.g. deforestation, desertification), and human conflict, hunger and disease [29]. As a result of their survey, and especially in consideration of the current trend in human population increase, the authors recommended radical changes in production practices (as well as regulations and consumption patterns).

In response to the need for changing animal agriculture practices, scientists have begun to rethink husbandry frameworks integrating both sustainability and animal welfare requirements. One such framework is Reflexive Interactive Design (RIO in Dutch) [1], which is organized as an iterative process including the phases of system and actor analysis, structured design and anticipated niche and structural change. Interaction designers will recognize in this iterative process the familiar requirements-design-(projected)evaluation cycle. An interesting aspect of this framework is that it regards farm animals as actors within the system and throughout the design process, by considering their capacities part of sustainable solutions. Here ACI could help the CHI community make a significant impact on sustainability in partnership, for example, with animal agriculture. ACI researchers could adapt HCI methodologies and practices to allow farm animals to participate in the design of sustainable farming including species appropriate animal-computer interactions. It seems to me that farming provides an opportunity to contribute to developing the kind of systemic and participatory frameworks for sustainable ecologies envisaged by Brynjarsdóttir *et al.* [2], in which computing interactions support the optimization of multispecies practices.

Beyond the farm, ACI could help CHI support the very biodiversity that sustains us, by exploring the design of computer interactions that can support wildlife. For one example, ACI researchers could design bee-centered systems that help bees cope with electrosmog [9], in order to try and revert their worryingly rapid decline. Above all, through *designing-with* other species, ACI could help us reassess what sustainability is about and reconsider our place within a shared, fragile ecosystem.

Concluding remarks

ACI as a discipline is still emerging, but far from being a niche area of little relevance, it is of direct relevance to HCI and thus to the CHI community. By placing hard constraints on design, ACI has the potential to push HCI's boundaries and deliver the most cutting edge, inclusive and ethical technology. Above all, ACI can keep CHI healthy by reminding it of what Haraway calls the "*foolishness of human exceptionalism*" [8]. ACI belongs at CHI because HCI is ACI.

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References

[1] Bos, A.P., Groot Koerkamp, P.W.G., Gosselink, J.M. J., Bokma S. (2009). Reflexive Interactive Design and its Application in a Project on Sustainable Dairy Husbandry Systems. *Outlook on Agriculture* 38(2), pp.137-145.

[2] Brynjarsdóttir, H., Hakansson, M., Pierce, J., Baumer, E.P.S., DiSalvo, C., Sengers, P. (2012). Sustainably Unpersuaded: How Persuasion Narrows Our Vision of Sustainability. *Proc. CHI'12*, ACM Press, NY, pp.947-956.

[3] Cheok, A.D.; Tan, R.T.K.C.; Peiris, R.L.; Fernando, O.N.N.; Soon, J.T.K.; Wijesena, I.J.P.; Sen, J.Y.P. (2011). "Metazoa Ludens: Mixed-Reality Interaction and Play for Small Pets and Humans," *Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions*, 41(5), pp.876-891.

[4] Chivian, E., Bernstein, A. (Eds.) (2008). Sustaining Life: How Human Health Depends on Biodiversity. Oxford University Press, NY.

[5] Golbeck, J., Neustaedter, C. (2012). Pet Video Chat: Monitoring and Interacting with Dogs over Distance. *Proc. CHI EA'12*, ACM Press, pp.211-220.

[6] Goode, D. (2006). Playing with my Dog Katie: An Ethnomethodological Study of Dog-Human Interaction. Purdue University Press.

[7] Grandin, T., Johnson, C. (2005). Animals in Translation: Using the Mysteries of Autism to Decode Animal Behaviour. Blossombury Publishing, London.

[8] Haraway, D. (2008). *When Species Meet.* University of Minnesota Press.

[9] Hasslberger, S. (Ed.) (2007). *Millions of Bees Die: Are Electromagnetic Signals to Blame?* http://www.newmediaexplorer.org/sepp/2007/03/06

[10] Hughes. B., Black. A. (1973). The Preference of Domestic Hens for Different Types of Battery Cage Floor. *Br Poult Sci*, v.14, pp.615–619.

[11] Kirksey, S.E., Helmreich, S. (2010). The Emergence of Multispecies Ethnography. *Cultural Anthropology*, 25(4), pp.545-576.

[12] Kohn, E. (2010). How Dogs Dream: Amazonian Natures and the Politics of Transspecies. *American Ethnologist*, 34(1), pp.3-24.

[13] Koneswaran, G., Nierenberg, D. (2008). Global Farm Animal Production and Global Warming: Impacting and Mitigating Climate Change. *Environmental Health Perspectives*, 116(5), pp.578-582.

[14] Lee, S.P., Cheok, A.D., James, T. K. S. (2006). A Mobile Pet Wearable Computer and Mixed Reality System for Human-Poultry Interaction through the Internet. *Personal and Ubiquitous Computing*, v.10, pp.301-317.

[15] Mancini, C. (2011). Animal-Computer Interaction: a Manifesto. *ACM Interactions*, 18(4), pp.69-73.

[16] Mancini, C., van der Linden, J., Bryan, J., Stuart, A. (2012). Exploring Interspecies Sensemaking: Dog Tracking Semiotics and Multispecies Ethnography. *Proc. Ubicomp'12*, ACM Press, pp.143-152.

[17] Mankoff, D., Dey, A., Mankoff J., Mankoff, K. (2005). Supporting Interspecies Social Awareness: Using Peripheral Displays for Distributed Pack Awareness. *Proc. UIST'05*, pp.253-258.

[18] McGrath, R.E. (2009). Species-Appropriate Computer Mediated Interaction. *Proc. CHI'09*, ACM Press, pp.2529-2534.

[19] Norman, D., Draper, S.W. (1986). *User Centered System Design*. New Jersey, Lawrence Erlbaum Associates.

[20] Noz, F., An, J. (2011). Cat Cat Revolution: an Interspecies Gaming Experience. *Proc. CHI'11*, ACM Press, pp.2661-2664.

[21] Paldanius, M., Kärkkäinen, T., Väänänen-Vainio-Mattila, K., Juhlin, O., Häkkilä, J. (2011). Communication Technology for Human-Dog Interaction: Exploration of Dog Owners' Experiences and Expectations. *Proc. CHI'11.* ACM Press, pp. 2631-2640.

[22] Panksepp, J. (1998). *Affective Neuroscience: The Foundations of Human and Animal Emotions*. Oxford University Press, NY.

[23] Pentland, A.S. (2008). *Honest Signals: How They Shape Our World*. MIT Press, Cambridge, MA.

[24] Resner, B.I. (2001). *Rover@Home: Computer Mediated Remote Interaction for Dogs*. Media Arts and Sciences MS, Cambridge, Massachusetts Institute of Technology.

[25] Reviews of ACI Workshop proposals for CHI '12-'13 (available on request), plus ACI SIGCHI'12 report: http://www.open.ac.uk/blogs/ACI/wp-content/uploads/2012/11/ACI-SIGCHI-report-final.pdf.

[26] Rogers, Y., Sharp, H., Preece, J. (2011). *Interaction Design: Beyond Human-Computer Interaction*. Wiley & Sons.

[27] Savage, J., Sanchez-Guzman, R.A., Mayol-Cuevas, W., Arce, L., Hernandez, A., Brier, L., Martinez, F., Velazquez, A., Lopez, G. (2000). Animal-Machine Interfaces. *Proc. Fourth International Symposium on Wearable Computers*, pp.191-192.

[28] Schweller, K. (2012). Apes with Apps: Using Tablets and Customised Keyboards, Bonobos Can Become Great Communicators. *IEEE Spectrum*, 49(7) (NA), pp.37-43.

[29] Stamp Dawkins, M. (2012). *Why Animals Matter: Animal Consciousness, Animal Welfare and Human Well-Being*. Oxford University Press, Oxford-NY.

[30] Touch Project, accessed 05.01.13: http://www.ludusanimalis.blogspot.co.uk/p/touch-project.html and http://www.playingwithpigs.nl/

[31] Ullman-Cullere, M.H., Foltz, C.J. (1999). Body Condition Scoring: A Rapid and Accurate Method for Assessing Health Status in Rodents. *Lab. Animal Sci*, v.49, pp.319–323.

[32] Weilenmann, A., Juhlin, O. (2011). Understanding People and Animals: the Use of a Positioning System in Ordinary Human Canine Interaction. *Proc. CHI'11.* ACM Press, pp.2631-2640.

[33] Wingrave, C.A., Rose, J., Langston, T., LaViola Jr, J.J. (2010). Early Explorations of CAT: Canine Amusement and Training. *Proc. CHI'10*, ACM Press, pp.2661-2664.