Designing for Wearability in Animal Biotelemetry

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ACI '16, November 16-17, 2016, Milton Keynes, United Kingdom
ACM 978-1-4503-4758-7/16/11.
http://dx.doi.org/10.1145/2995257.3012018

Abstract
This research presents a preliminary study conducted on a cat fitted with biotelemetry devices. The aim was to explore the feline's wearability experience of bearing off-the-shelf products. The cat's reactions to the device presence were recorded and findings suggest the need for a design approach centred on the wearer. A *wearer-centred* framework to inform the design of biotelemetry interventions for animals is then proposed.

Author Keywords
Biotelemetry; wearability; wearer-centred design; animal-computer interaction.

ACM Classification Keywords
H.5.2: User-centred Design

Introduction
Biotelemetry devices (box 1a) are animal-borne machines used by humans (e.g., pet carers, wildlife researchers, farmers) interested in acquiring biological data from animals. Consequently, their design tends to be driven by *user-centred* values with respect to the needs of human users. For example, ecologists may use coloured tags for marking the animals they are studying as they need to easily identify individuals during field observations [1].

Box 1a: *Biotelemetry* is the practice of monitoring animals by means of body-attached electronic devices such as radio transmitters, satellite trackers, or bio-sensors. Since the 60s, this technique has been widely used for remotely acquiring ecological (e.g., locations), physiological (e.g., heart rate), and behavioural information (e.g., movements) from wild and domesticated fauna (Review in: [8]). For example, migratory birds can be tracked to study their flying route and behaviour otherwise impossible to observe.

Box 1b: Impacts have been extensively reported in biotelemetry literature [2]. They can be physically (e.g. fur abrasion), physiologically (e.g. variations in the metabolic activity), or behaviourally manifested (e.g. abnormal grooming in the attempt of removing the foreign body) (review in [4]).

However, as *wearers*, animals are directly affected by having to carry monitoring systems. For example, the colour of a tag can increase the animal detectability by ill-intentioned humans, potential predators or prey [2] impinging on their welfare.

The interaction between the device and the (animal) body has been defined as *wearability* [3]. The physical and sensory perception that animals may have when wearing tags is at the base of device-induced impacts (box 1b). These alterations impinge on the animal welfare and consequently, on the validity of recorded data [5]. For example, when studying the foraging behaviour of penguins using attached transmitters, tags can increase drag, thus reducing the swimming speed and altering the very hunting patterns being investigated [9]. Therefore, both on scientific and ethical grounds, there is a need to decrease negative effects and improve animals' experience when they come in contact with wearable devices.

These considerations raise the question as to how to design wearable devices consistent with the needs of *wearer interactors*, in order to decrease their effects. In User-Centred Design (UCD), an interactive technology is designed with respect to the users' characteristics, activities and environments in which they live. Animal-Computer Interaction (ACI) designers have applied UCD for the development of technologies with which animals can actively interact. Their aim has been to bring the perspective of animal users into the design of devices used by them (e.g., [7]). This research proposes the application of UCD for the development of wearable devices used on animals, approaching the issue under the wearer's point of view. The goal is to design for good wearability considering the wearers of biotelemetry technologies as main stakeholders.

This paper presents a preliminary study whose aim was to examine the wearability of trackers commercially available for cats (*Felis catus*). The study revealed a general lack of wearer-centred perspective in device design. Consequently, the development of a framework through which to inform the design of wearer-centred biotelemetry interventions has been started. An early-stage version of such framework is presented in [6]. Its aim is to support design solutions in ACI and other disciplines (such as biotelemetry) and bring the perspective of animals as wearer interactors into the design of technologies intended for them.

Wearability of off-the-shelf devices

A study on a cat was carried out. It aimed to test the experimental design for understanding the reaction of the participant to wearing a device, and to evaluate the equipment with respect to wearability aspects [3]. Two different devices were tested (Fig. 1) in order to compare the wearer's reaction to different device sizes, weights and shapes. Following the recommended attachment position for cats, tags were originally placed on the back of the animal's neck by means of a cat-specific adjustable collar (9 g).

A three years old domestic male cat was recruited. His weight (6.5 Kg) was accordant with device seller's recommendation that cats should weigh more than 4.5 Kg. An indoor cat was chosen in order to facilitate time standardization of observations, being the cat constantly on view. Prior to the study, the participant was not used to wearing collars.

Experimental design

The participant was observed in his habitual environment without being restricted in order to avoid stress induced by habit changes. Data was collected

Box 2: B was performed (n=1) for 5.28s (location: snout) during control; (n=7) for a total of 61.98s with the activity monitor; (n=13) for 124.8s with the GPS. In the last two cases, the cat scratched his neck or throat (where devices were attached) 5 and 12 times while wearing the activity monitor and GPS respectively. The cat performed D twice (n=2) during the control; (n=10) with the activity monitor; (n=12) with the GPS. C was never performed during the control (obviously, in this case, since no device was attached) but an increment was observed between activity monitor (n=0) and GPS phases (n=15 for 215.6s). Frequency and duration of A were: during the control (n=4; 14.32s); with the activity monitor (n=12, 291.31s); with the GPS (n=11, 61.58s). The cat never groomed his neck/throat during the control and activity monitor phase, but he did it (n=3) times while wearing the GPS.

through direct observations of behaviour, noting this down on a data sheet and video-recording it.

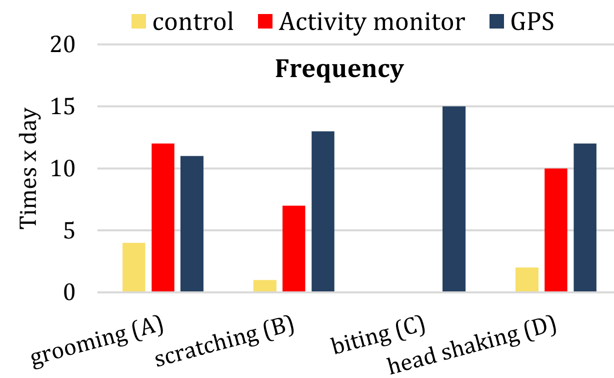
Three conditions were tested in the following order: 1) control: without wearing anything, 2) wearing a collar with the activity monitor mounted on it, and 3) adding the GPS unit on the same collar. Behaviours tested were A) grooming, B) scratching, C) biting the device, and D) head shaking. The cat (n=1) was monitored for 3 consecutive days, each day under a different experimental condition (i.e. 1, 2, 3). For future observations on other cats, order of the conditions will be randomised in order to avoid order bias.

The sampling technique consisted of focusing on the individual and recording the above-listed behaviours (i.e. A, B, C, D) for 20 minutes each hour, for a total of 8 hours per day (9am-4pm was selected due to owner's availability). This was done in order to maximize accuracy. The parameters measured were:

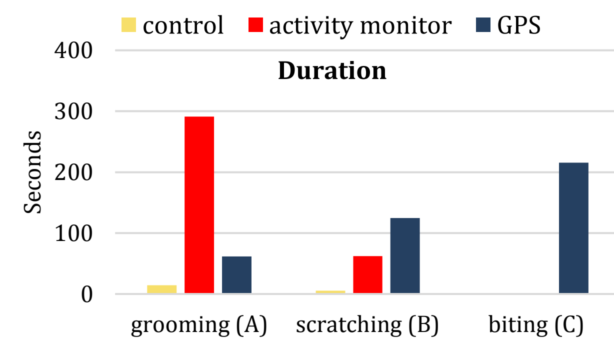
- for (A) and (B): frequency (how many time the behaviour was performed), duration (for how long: in seconds), and location (where the licking was directed: neck and throat, or any other body part);
- for (C): frequency and duration;
- for (D): only frequency.

The experiments were approved by The Open University's Animal Welfare and Ethical Review Body and conformed to its ACI Research Ethics Protocol.

Findings
Results were extrapolated from a total of 160 effective minutes of observation each day, for a total of 480 minutes. They are detailed in box 2, and displayed in graph 1 and graph 2.



Graph 1. Times per day in which behaviours were observed



Graph 2. Total duration of grooming, biting and scratching

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Results show how the GPS device gets in the way of the cat with increased frequency in comparison with the small activity monitor as signalled by the behaviours of biting, scratching, and head shaking. The contrast is even more striking when this data is compared with the data gathered during the control phase (without collar).

Figure 1. Tested devices were
- activity monitor based on accelerometer technology sold in the human wearable market (Xiaomi Mi Band; 5 grams; 36x12x9mm);
- GPS tracker specifically designed for pets and sold in the pet wearable market (Tractive; 41 grams; 51x41x15mm).

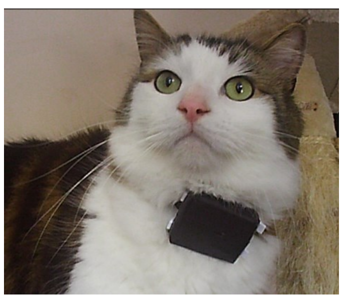

Figure 2. Tags attached on the participant slipped under his chin. They were covered with black rubbery tape to record biting marks.

It is also shown how the time the cat spent grooming, biting and scratching increased with the increasing obtrusion of the devices. In particular, biting the device, scratching in proximity of the neck, and head shaking increased with the activity monitor and even more with the GPS, showing a disturbance possibly due to both the method of attachment and the device.

Although tags were positioned on the back of the neck, they slipped under the chin (Fig. 2). This likely increased annoyance toward the device, and highlights the inappropriateness of the attachment proposed by sellers. Episodes of potential hazard for the cat's safety were observed. In a particular instance, the participant was roosting on a high spot of a multi-shelf cat tree; suddenly he diverted his attention to the tag and started biting and grasping it with both his forelegs, standing on his hind limbs. While attempting to remove the device, the cat compromised his balance and risked falling off the tree perch (160 cm high). This raises the question as to whether these kind of distractions in a wild environment might expose an animal to riskier circumstances than they would usually experience. For example, if an animal became distracted by the tag, his alert behaviour might be affected, resulting in a greater chance of being caught by a predator. One further issue highlighted is that, although the tested GPS tag is sold for the purpose of monitoring cats, our findings indicate that it is not as "cat-friendly" as one would expect it to be, given the increment of cat's irritation registered. Overall, the findings highlight a need to re-think the design of such devices in accordance with the characteristics and requirements of animal wearers.

In conclusion, our preliminary data supports the whole premise of the proposed research that is: *i*) there is a need to systematically rethink the perspective from which animal biotelemetry is designed; *ii*) as a step in the direction towards good wearability, an appropriate framework could help inform the wearer-centred design of biotelemetry.

References

1. Burley N., Krantzberg G., Radman P. 1982. Influence of colour-banding on the conspecific preferences of zebra finches. *Animal Behaviour 30*, 2: 444-455.
2. Casper R.M. 2009. Guidelines for the instrumentation of wild birds and mammals. *Animal Behaviour 78*, 6: 1477-1483.
3. Gemperle F., Kasabach C., Stivoric J., *et al*. Design for wearability. In *Wearable Computers, 1998. Digest of Papers. 2nd Int Symp on* IEEE, 116-122.
4. Kenward R.E. 2000. *A manual for wildlife radio tagging*. Academic Press, London.
5. Murray D.L., Fuller M.R. 2000. A critical review of the effects of marking on the biology of vertebrates. In *Research techniques in animal ecology: controversies and consequences*, B.L.A.F. TK Ed. Columbia University Press, New York.
6. Paci P., Mancini C., Price B.A. 2016. Towards a wearer-centred framework for animal biotelemetry. In *Proc Measur Behav 2016, Dublin, 440-444*.
7. Robinson C.L., Mancini C., Van der Linden J., *et al*. 2014. Canine-centered interface design: supporting the work of diabetes alert dogs. In *Proc ACM, CHI'14*, ACM Press, 3757-3766.
8. Wilmers C.C., Nickel B., Bryce C.M., *et al*. 2015. The golden age of bio-logging: how animal-borne sensors are advancing the frontiers of ecology. *Ecology 96*, 7: 1741-1753.
9. Wilson R.P., Grant W.S., Duffy D.C. 1986. Recording devices on free-ranging marine animals: does measurement affect foraging performance? *Ecology, 67*: 4, 1091-1093.