Ethical challenges in the age of bio-logging: guilty until proven innocent.

The history of right or wrong

The history of animal experimentation is vast, with records dating as far back as 384 BC with Aristotle's early works on living animals and Galen's physiological experiments on pigs, monkeys and dogs in 130 – 201 AD[1]. The ethics and moral concerns surrounding such experiments were relatively void in this era compared to today, and procedures which would now be considered monstrous, even criminal or acts of animal cruelty (such as live vivisection without anaesthetic[2]) were frequently practiced. At a time before the concept of animal sentience had been developed, animal experimentation was rarely considered 'wrong' and one might argue scientists had the freedom to adopt an innocent until proven guilty approach to their research.

This was the case at least up until towards the end of the 19th century when Darwin's works on the Origin of Species[3] raised the profile of animals – specifically their biological likeness to man - and animal welfare, and in doing so improved substantially the ethical scrutiny and moral obligations of animal experimentation, while simultaneously encouraging further research. As a result the routine use of animals in experiments increased markedly in the subsequent decades throughout the biomedical sciences[4].

In 1959 the Three Rs (*replacement, reduction and refinement*) were introduced by Russell and Burch[5] effectively outlining that animals should not be used in any research unless they are absolutely essential for the investigations being undertaken, and that steps should be taken to refine animal welfare as much as possible in all studies. These rules soon became the guiding principles of ethics in animal experimentation and the use of animals peaked in the late 20th century, before steadily declining due to public pressure[6]. The Animals (Scientific Procedures) Act 1986 was later adopted, and revised in the decades to follow. The numbers of study animals continued to decrease alongside the refinement of techniques and the development of available, alternative methods to replace their use.

The most recent update in animal experimentation took effect in 2013 (Directive 2010/63/EU) which strengthened the current legislation, improved welfare conditions for any remaining test subjects and reinforced the principles of the Three Rs. These principles are today sternly upheld by the Home Office and remain the leading authority on ethical decisions in animal experimentation currently, forming the method of deciding whether or not an experiment is 'right' or 'wrong'.

Ethical challenges in a new era

In the recent era of digitalisation and the 'internet of things'[7], the newest challenge in animal experimentation ethics has arisen through the extensive development of bio-logging (or telemetry) technology[8] and through the opportunities that these devices present for studying

wild, cryptic animals. Telemetry devices are able to collect unique, vast datasets which were previously impossible to obtain[9] and this, along with numerous other benefits, has led to the rapid uptake of their use in research, with a plethora of studies deploying bio-logging devices on animal subjects worldwide[8].

Researchers deploy telemetry for a multitude of well-justified reasons, such as to explore the transmission of bovine tuberculosis between cattle and badgers[10]. Experiments of this type can often have very large, positive impact thanks to the great advances in the understanding of the behaviour of individuals and populations, and the resulting management advice and conservation strategies which can arise[e.g. 11]. Such research frequently attracts substantial media attention, which in turn highlights the importance of these, and other animal issues and in doing so raises awareness of animal welfare and ethics in animal experimentation in general.

At the onset of the bio-logging era (in the 1960s[12]) the direct impact of telemetry on animals was considered negligible[e.g. 13]; for example early deployments on marine mammals had little to no mention of tag impact. Later studies (in 1998) went as far as to not even primarily collect data on the subject individuals on which the devices had been attached, but rather exploited the animals merely as a tool to collect environmental data for alternative research aims[14]. Other authors had however, while continuing to embrace the use of telemetry devices, noted their concerns on the potential impacts of the tags – from at least as far back as 30 years ago[15].

An influential review by McIntyre (2014)[16] (specifically targeting marine species) highlighted the particularly concerning lack of consideration for tag influence between 1965-2013, finding that only 14 in 620 publications had reported any information on device influence. This was a very timely journal - having been published shortly after what remains possibly the most important and prominent example of animal-tagging gone 'wrong': Saraux *et al*., 2011[17]. This Nature publication examined the impact of flipper banding, or ringing, on the survival of wild, free-ranging penguins. The small rings used to mark individuals were perceived to have little to no effect; ringing techniques had been used almost ubiquitously for decades prior on a plethora of avian species[18]. However, in this study the authors documented that ringed individuals had an increased mortality by up to 30 percent, with potentially disastrous consequences at population level.

Largely due to its scale, this study was considered one of the most systematic studies of its kind and its findings inevitably sparked controversial debate, with the author personally commenting that the principal research tool [the rings] was no longer ethical[19]. It also raised a clear, new challenge – that the very tool used in the research was affecting the results obtained; revealing a paradox in animal tagging. Further, given that such a small device could have such a large effect, it would suggest that those other studies making use of much larger bio-logging tags would pose a significant risk; investigations had now increased in their importance to ensure that the ethics involved were sound[16]. Later studies to this end identified, for example, compounding issues of tag impact coupled with worsening of environmental conditions, which led to exacerbated, tag-induced harm[20].

There are also some other potentially hazardous consequences - in addition to the direct impact of tagging, an equally pressing ethical dilemma for this type of research is the now rising occurrence of malicious public interference with tagged animals[21]. Cooke *et al*., 2017 documented that in a number of cases attempts had been made to hamper tagging studies, where tagged animals were the specific targets of detrimental abuse. For example in India where data from a GPS tracking collar were hijacked to locate and kill an endangered Bengal tiger. In western Australia publicly available data on tagged sharks, which were originally designed to act as an early-warning system for beach-goers, were instead used maliciously by third parties to find and kill the individuals in order to minimise potential, fatal encounters with humans[22].

These types of incidents highlight potential pitfalls in the ethical legitimacy and morals surrounding bio-logging experimentation and lead us to continue to question once more whether they are 'right' or 'wrong'. Nevertheless there has been a continued and considerable increase in public interest surrounding the use of telemetry devices in conservation research[e.g.23-24].

Guilty until proven innocent

Evidently tagging animals can, and does in a few cases, pose significant consequences to the subject animal. When asked the question as to whether or not this makes this form of animal experimentation 'wrong', one must ultimately then, in light of this evidence, conclude this as true - as for such studies to be unequivocally 'right' they would need to be undertaken without at all altering the behaviour of the subject animal; such is the implicit notion of telemetry studies.

Thus insisting on an answer of 'right' or 'wrong' for animal experimentation involving telemetry would thus conclude that all studies are inherently the latter. This seems an altogether impractical conclusion because clearly there are substantial benefits to this type of research. The subject of animal experimentation by means of telemetry is perhaps too vast, with the potential outcomes bearing too much gravitas, to approach an appropriate answer through the use of a polar question - perhaps then an approach via discussions centred on the Three Rs would be more useful in ascertaining morality.

For studies which necessitate the collection of telemetry data on wild animals, *replacement* is, of course, not possible; telemetry data simply cannot be obtained without tagging animals. Indeed with specific regard to telemetry studies the Three Rs official website makes no mention of replacement[25]; instead only reporting the necessity to *reduce* animal numbers wherever possible and ensure that steps are taken so that individual animal welfare is not compromised [*refinement*]. The only strategy which then remains is to undertake all practical steps towards fulfilling the requirements of these guiding principles and mitigate any detriment to the animal.

Researchers working in the field of bio-logging should be proactive in identifying the issues that challenge the ethics of their research[21]. At the very least they should ensure that everything is done to meet two key aims: first, that any tagging activities undertaken are successful - nothing could be more 'wrong' than to put the animal(s) in question under the undue stress, discomfort and potential harm from tagging and then for the researcher to receive nothing to show for it. Secondly, tag-induced bias (such as in the form of drag for an external device) must be minimized so that the utility of the data acquired is maximised in order to justify the costs – this should include the quantification of any known tag-induced effects so that results can be put into perspective[26].

Animal experimentation is indubitably important to the development of science; 75 of the 98 Nobel Prizes awarded in the field of physiology or medicine were all achieved through the use of data collected on animal subjects. The field of telemetry has itself made huge, positive advances through the use of animal experimentation, with the potential to transform fisheries management[27], combat global species decline[28], support biodiversity monitoring[29] and much more.

Saraux's and Wilson's studies are two good examples of cases which raised important ethical and practical considerations with regards to this field of research and questioned the morality of animal tagging in general. In addition they have fuelled the debate into animal welfare relating to telemetry studies, and much like Darwin's work in the 19th century, have acted as catalysts to encourage refinement and good practice, and further improve the scrutiny of this type of research.

Detrimental impact on animals is inevitable with telemetry and tracking studies – in this sense bio-logging scientists are always guilty until proven innocent[30-31]. But by following the guiding principles outlined by the Three Rs, alongside collaborative support and discussion from experts in this field of research, the era of bio-logging can nonetheless continue to grow successfully and strive towards making animal experimentation in this context always as 'right' as possible, along with its conscience.

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