Designing for the Animal User:  
Smart Controls for Mobility Assistance Dogs

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Dedicated to my family:
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Marcelo
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and Mila
Abstract

This research explores the mismatch between mobility assistance dogs’ (MADs) current working environments, their characteristics and capabilities as users and their resulting UX. This thesis presents the design of a set of smart controls for MAD use, including the development and application of a series of mixed method approaches for the systematic analysis of MADs behaviour while interacting with technological devices. These approaches were used to define a set of MAD user requirements with which to evaluate their UX and inform the design of controls. The research consists of five phases during which the main research question “How can interfaces for MAD users be designed in a way that provides them with a good UX? was addressed. In the course of the research six empirical studies were conducted, to gather recorded observational data of MADs’ interactions with existing and prototyped controls – in two distinct settings. Data was also collected from the MADs’ handlers: from their trainers and their human partners. The research has generated a series of methodological, design, theoretical, and animal welfare contributions, which included: i. a tail wagging ethogram for the assessment of MADs’ affect-based interactions with technological devices; ii. a method for evaluating animal usability (MEAU); iii. an approach to measuring MADs’ levels of confidence while interacting with technological devices; iv. an Ethical Toolkit for ACI Research to prompt ACI practitioners to articulate their ethical research related values; v. an animal-centred design framework (ACDF) in which a user-centred approach to design technology for animal users is proposed; and vi. a set of smart controls whose use was confirmed to improving MADs’ UX.
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List of Abbreviations

ACDF Animal-centred Design Framework
ACI Animal Computer Interaction
ADI Assistance Dogs International
ATS The Advanced Training Stage
BPAC Blue Prototype Access Control
DAD Diabetic Alert dog
DFG Dogs for Good
ETAR Ethical Toolkit for ACI Research
HCI Human Computer Interaction
ID Interaction Design
MAD Mobility Assistance Dogs
MEAU Method for Evaluating Animal Usability
PD Participatory Design
SIAC Standard Issue Access Control
UCD User-centred Design
UX User Experience
YPAC Yellow Prototype Access Control
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1. Introduction

Humans and animals have been interacting with each other for millennia, forming varied relationships that, due to the evolutionary advantages held by humans, are heavily anthropocentric in nature. This advantage has arguably influenced the way in which animals have evolved and shaped the way we understand our interactions with them, resulting in the animals’ perspective, and thus experience, being disregarded. The predominant human-centric perspective is most noticeable when humans and animals interact within human society, where the environments, as well as artefacts within them, are informed by the needs and preferences of the human stakeholder.

Among the many human-animal relationships, the bond between dogs and humans is especially noteworthy due, in part, to how involved dogs have become in human society. In particular for the many dog-human partnerships that require dogs to work within our human-centric contexts and at times actively interact with them, such as the partnerships between humans and assistance dogs. Assistance dogs are specially trained to carry out a range of assistance-based activities on behalf of their humans, such as providing support for visually impaired people to navigate their environment, alerting people who suffer from diabetes when their insulin level is dangerously low, acting as a security tether for children with autism in public spaces, and executing commands to assist people with mobility-related disabilities. My research focused on this last type of assistance dogs, commonly termed Mobility Assistance Dogs (MADs) who execute tasks on behalf of their human partners, such as those related to self-care, mobility and other physical activities including opening doors, retrieving objects and switching lights (ADI, 2020).

To assist their human partners, MADs are required to interact with a wide variety of products and interfaces in diverse environments.; however, most of the environments and the artefacts in them are designed from a human-centric perspective that fails to recognize MADs as legitimate users and therefore fails to meet their needs (Mancini et al., 2016). Failing to meet MADs’ needs does not usually prevent them from being able to assist their partners but it does result in them facing significant interaction-based challenges that impact their ability to do so in a consistent and successful manner and which ultimately affect their welfare (Mancini et al., 2016) and user experience (UX) (Ruge and Mancini, 2019). Figure 1 shows some of the situations and challenges MADs
encounter when carrying out tasks on behalf of their partners, such as having to jump up to reach out-of-reach buttons, having to activate switches designed for human fingers, or having to hold and manipulate small objects such as credit cards with their mouths.

Figure 1: Everyday mismatches between MADs and their working environments

UX design is the field which, broadly speaking, investigates the quality of experience a user has when interacting with a product or service. It is described as the study of the dynamic, context-dependent, and subjective specific experience that stems from the range of potential benefits users may derive from using a product, and/or service (Law, 2009). The study of the UX is central to the discipline of interaction design, which is concerned with the design of interactions between users and products, in a way that the products being designed enable the user to achieve their objectives in the best way possible (Lowgren, 2013). In pursuit of this aim, interaction designers have developed methods that enable them to research the needs and preferences of their intended users to ensure that they are met by the interactive products they design. Historically, the term ‘user’ has exclusively referred to humans, with the discipline as a whole tending to disregard the animal user.

This gap is now being addressed by the emerging discipline of Animal Computer Interaction (ACI), whose aim is to raise awareness about the legitimacy of the animal as a user and promote the advancement of methods and approaches to inform and enable the design of products from an animal-centric perspective (Mancini, 2017b, Mancini, 2011, Mancini, 2017a). In fact, a significant amount of work has been done related to investigating dogs’ interactions with interactive technology such as the early work of Resner (2001) and his use of human-centred design frameworks to inform the design of a device to mediate playful interactions between dogs and humans; or more recently
the work of Byrne et al. (2019) which focused on assessing a working dogs’ potential based on their ability to interact with a robot. And, more specifically, related to the interactions of assistance dogs with interactive technology such as those investigated by Mancini et al. (2016) who sought to extend accessibility to assistance dogs by addressing the mismatches between the dogs’ working environments and their characteristics as users (work which has motivated this research); or Robinson et al.’s (2014) investigation of methods towards the design of a canine-centric alarm for diabetic alert assistance dogs (§2.4). Yet in spite of the sizable body of existing work, MADs are still required to interact with devices that are not designed for their characteristics and capabilities as users. The research presented here aims to apply an animal centred design approach to address the multiple aspects of MADs’ interaction with specific devices and, based on reliable data, enable the evaluation of the extent to which a design meets their needs and affords them a good UX.

Arguably, one can never directly represent the experience of another. This is especially so when designing for other species, whose experience is shaped by different sensory, physical, and cognitive characteristics and capabilities. However, by implementing a design methodology, based on the tenets of ACI (Mancini, 2017b, Mancini, 2011) I aimed to develop methods that are “sufficiently robust but also versatile enough to help deal with the challenges, pitfalls and tensions” (Mancini, 2017b) inherent in multispecies design and which, as ACI practitioners, guide us in actively seeking to “reduce the arbitrariness of or biases in choices made during the design process“ (Mancini, 2017b).

Furthermore, because ACI is largely founded in interaction design, a discipline described as “a process of incremental approximation where mutual understanding between parties derives from shared practices and associations formed during an iterative process of trial and error“ (North, 2016); my research sought to take an animal centred design approach to design for animal users, by gaining a deep understanding of MADs as users. Finally, although this research is focused on MADs, the contribution to knowledge presented here aims to be applicable to other animal users, and useful to other ACI practitioners.
1.1 Research Questions

This research investigated the process of designing a technological device for MADs that aimed to address the inconsistencies between their requirements and capabilities as users, and the human-centric design of the devices they are commonly required to interact with on behalf of their human partners. Pursuing these aims raises a fundamental research question:

\[ rQ - \text{“What kind of interfaces would need to be designed for MAD users in order to provide them with a good UX?”} \]

The question is addressed by investigating methods and approaches from the disciplines of interaction design (ID), ACI and ethology and adapting or, in some cases, reformulating them to better meet the MADs' user requirements. In particular, this thesis focuses on the redesign of tangible interfaces used by MADs, such as access controls and light switches; a focus which is motivated by Mancini et al.'s (2016) previous work which highlighted the urgent need for such design.

To enable the systematic investigation of the fundamental research question, the following supporting questions were formulated:

\[ srQ1 - \text{“In order to design for MADs, what do ACI practitioners need to know about them as users?”} \]

For designers to design for users other than themselves, they must first understand their intended users’ characteristics, capabilities, motivations, behaviours, and their context(s) of use, meaning the context(s) in which the intended users may use a product or system (Lowgren, 2015, Preece, 2015). As previously mentioned, doing so for another species presents explicit challenges related to the differences that exist among human researchers and animal users; and their implications on the design process. However, the focus of this question is determining what information a designer needs to know about the animal user, in this case MADs, in order to, despite these differences, reach a good enough understanding of them as users of interactive products. To address this
question systematically, we aim to investigate methods commonly applied towards the understanding of human users, that will help us understand MAD users, such as direct observations and secondary research. Additionally, we aim to gain an understanding of MADs’ contexts of use by conducting a series of formative studies at the facilities of our research partner Dogs for Good (DFG), introduced in §3.1, in which we observed MADs’ working environments and the devices and stakeholders within them that they commonly interact with. Doing so allowed us to reach a systemic understanding of how the elements within their context(s) of use influence the quality of MADs’ UX.

sQ 2 – “What methods might ACI practitioners use to inform the design and evaluation of canine-centric interfaces?”

The multidisciplinary nature of ACI results in a methodological toolkit that spans across a broad spectrum of domains and makes use of a diverse repertoire of tools and techniques which have different origins and have been developed for different purposes. Thus, in order to meet the animal users’ needs, as an ACI practitioner, it is very important to understand the origin and purpose of the methods available, and, based on the specific animal users’ characteristics and context of use, choose ones that appear to be the most appropriate or if needed, customize them accordingly. Because this research addresses the design of interfaces that aim to provide MADs with a good UX, the methods used need to apply to multiple aspects of MADs’ interactions including the process of design, the evaluation of the design itself and its impact on their UX. To address these different aspects, I considered what methods might be needed to inform a canine-centric approach to designing for MADs, and what aspects of MADs use of tangible interfaces would need to be considered in order to measure the quality of their UX. To do so, a typical design ID process consisting in establishing user requirements, designing alternatives, prototyping and evaluation (Preece, 2015) was carried out, during which various methods were applied, developed, and tested. Additionally, a series of observational studies of MADs interacting with an access control, a device which they commonly operate on behalf of their human partners, and prototypes of the designs I developed were conducted. These produced a set of behaviours that evidenced to provide accurate information about MADs’ use of tangible interfaces,
specifically in relation to usability and UX. These behaviours were further investigated during a study of three MADs interacting with my final smart control design, during which a comprehensive evaluation of the devices’ impact on their usability and their UX was conducted.

srQ3 – “What ethical implications arise when designing interactive canine-centric interfaces”

In the 2017 paper Towards an animal-centred ethics for Animal-Computer Interaction, Mancini (2017a) proposes an ethical framework in which a comprehensive set of guidelines for ACI practitioners to consider when designing technology and when conducting research are presented. However, ACI researchers must also consider the implications this has for their role as designers. Because in contrast to a role which can be broadly described as one of facilitation when working with humans; when working with animals, the role becomes one of active participation, requiring ACI practitioners to act as interpreters and representatives of the animal user throughout the entire design process. In order to address this question and prompt ACI practitioners to active ethical reflection, I formulated an Ethical Toolkit for ACI Research (ETAR) informed by my experience during the course of the research (§9.2).

To summarize, the fundamental research question (rQ - “What kind of interfaces would need to be designed for MAD users in order to provide them with a good UX?”) was addressed thorough the following contributions this research aimed to provide:

1) Designing a set of dog-centred smart controls to support the work of MADs and improve their UX.

2) Formulating a series of canine-centric methods and approaches for the development of interactive products for MAD users, including a 6 Factors User Research Model for (§4.2); a Tail Wagging Ethogram (§6.1.2.6) aimed to evaluate MADs’ affect-based interactions with technological devices, a Method for Evaluating Animal Usability (MEAU) aimed to evaluate MADs’ usability based interactions (§6.2.2), and an Animal-Centred Design Framework (ACDF) aimed to serve as a guide for ACI practitioners when designing for and evaluating the canine UX (§9.3).
3) Formulating an Ethical Toolkit for ACI Research (ETAR) for ACI practitioners to actively reflect on their ethical perspectives and decisions while designing interactive products for the animal user (§9.2).

1.2 Chapter Overview

The subsequent chapters of this thesis are structured in five phases presented as follows:

Phase 1: Conceptual Framing
Chapter 2 – Review of Literature
This chapter provides an overview of the history of the relationship between animals and humans, focusing on the relationship between dogs and humans, and its evolution into active working partnerships such as those of assistance dogs, specifically MADs. It then examines the disciplines of Interaction Design and Human Computer Interaction, discussing the concepts of User Centered Design and User Experience and their use within a common design process. The next section focuses on ethical perspectives within the practice of design including those of micro-ethics, situational ethics, and in-action ethics. The chapter concludes with an overview of ACI’s aims and foundational perspectives, a review of literature related to the design of technological devices for canine users, and a summary of its main contributions and implications for this research.

Chapter 3 – Methodology
Chapter 3 introduces our research partner Dogs for Good (DFG), a UK based assistance dog training charity. It then describes the main ethical considerations addressed during the research. It concludes by discussing the overarching methodological approach taken during the research, and the methods and approaches chosen for the various studies presented in this thesis.

Phase 2: Understanding MAD Users
Chapter 4 – Review of Canine User Literature
This chapter addresses the first supporting research question (srQ1 - “In order to design for MADs, what do ACI practitioners need to know about them as users?”), with a focus on investigating MAD users’ characteristics, capabilities, motivations and behaviours. It
adapts a human-centric tool for conducting user research, the 5 Human Factors Model (Kumar, 2012) for MAD use; proposing a new 6 Factors User Research Model which takes into account a users’ physical, social, cultural, cognitive, emotional, and sensory characteristics and capabilities. Furthermore, it provides a set of initial MAD user requirements and considerations that relate to the factors proposed in the model, and potentially applicable to other canine-related research.

Chapter 5 – Empirical MAD User Research
This chapter presents two studies - the first focused on MADs’ developmental stages, and the second on the Advanced Training Stage - aimed at understanding MADs’ current contexts of use, including the roles of the stakeholders involved, the artefacts and devices they commonly interact with and the types of interactions they have with them. Results included a series of MAD and human user journeys which when analysed provided a robust view of MADs’ supporting ecosystem and how the elements within it influence their UX. Additionally, an emergent set of MAD user requirements were defined.

Phase 3: Investigating MADs’ Interactions with Technological Devices
Chapter 6 – Investigating MADs’ Affect and Usability-based Interactions
This chapter addresses the second supporting research question (srQ2 “What methods might ACI practitioners use to inform the design and evaluation of canine-centric interfaces?”) by reporting on two studies (§6.1 and §6.2) carried out at the facilities of DFG. The first study focused on MADs’ affect-based interactions with an access control, and the second, on a comparative study of MADs’ interactions with an existing access control and a set of prototypes previously developed by Mancini et al. (2016). Data collected during the studies was analysed using an iterative approach which allowed the definition of a set of behaviours to be observed that would provide an accurate measure of the dogs’ UX.

Phase 4: Designing for MAD users
Chapter 7 – Evolution of a Design
Chapter 7 reports on the process of designing a device for MAD users. It is organised into three sections and each presenting an iteration in the development of the design. The first iteration §7.1, describes the process from initial design concept to low-fidelity prototype; the second §7.2, describes the development, construction, and heuristic and empiric evaluation of a set of prototypes by three MAD partnerships; and the third §7.3 describes the development, construction and testing of a set of high-fidelity prototypes by six MAD users.

Chapter 8 – Evaluating a Design
Chapter 8 presents a consolidated approach to evaluating the MAD UX and reports on the development, construction and evaluation of the final iteration of a set of high-fidelity smart controls and their use and evaluation by three MAD partnerships.

Phase 5 – Outcomes and Conclusions
Chapter 9 - Outcomes
Chapter 9 presents the findings of the research and is organized into three main sections. The first §9.1, reports on the final set of MAD user requirements and design specifications for the smart controls. The second §9.2, addresses the third supporting research question (sRQ3 - “What might be the ethical implications of working with MADs as our intended users?”) by presenting an Ethical Toolkit for ACI Research (ETAR). The third §9.3, presents a summary of the development process of the Animal Centred Design Framework (ACDF) and provides a detailed overview of the methods presented in the ACDF while critically discussing its future application.

Chapter 10 – Conclusions, Limitations, Future Research, and Final Remarks
To conclude, this chapter restates the main and supporting questions for the research and presents a summary of the research findings. The specific contributions to knowledge that were advanced in each stage of the project are stated, whilst acknowledging the research’s limitations. Suggestions for future research relating to the investigation of design for MAD, canine, and animal users are described. The chapter concludes with a series of personal reflections on the research.
1.3 Research Map

The following figure presents a visual representation of the research activities carried out during each phase of the research, the chapters belonging to each phase, the empirical studies carried out, and the main content of each chapter. The colours used to identify the different research phases are used throughout the remainder of the text as a means to orient and guide the reader through the thesis.
Phase 1: Conceptual Framing
2. Review of Literature

The following chapter presents a review of literature related to themes relevant to this research including human-canine partnerships, with a specific focus on MADs; the disciplines of ID and HCI and their role in designing for canine users; the application of ethics in design; a review of canine related ACI literature and the role of situated ethics in ACI.

2.1 Mobility Assistance Dogs

2.1.1 The Evolution of the Human-Canine Relationship

Many scholars believe animals to be an integral part of human development and central to human society; as DeMello states “We are surrounded by animals. Not only are we ourselves animals, but our lives, as humans, are intimately connected with the lives of nonhuman animals.” (DeMello, 2012). The ways in which human and animal relationships have evolved are influenced by how animals’ lives intersect with human society. For example, where they exist - whether it be in our homes, on farms, in scientific laboratories, in zoos, or in nature - partly, determines an animals’ degree of domestication; understanding domestication as a “process (directed at achieving clearly identified goals) in which humans deliberately and with forethought assume control over the domesticate.” (Zeder, 2012).

Dogs, are considered to be the first species to be domesticated (Grandin and Deesing, 2013), and are described as having a period of proto-domestication dating back 35,000 years; with Ovodov et al. (2011) reporting the discovery of 33,000 year old dog fossils in Siberia; and others claiming domestication to have occurred between 5,400 to 16,300 years ago (Pang et al., 2009, Savolainen, 2002). Yet, regardless of the exact timing of when the process of dogs’ domestication began, they are considered to be the species which best exemplifies domestication and which has established “the most intimate and complex relationships with humans” (Serpell and Barrett, 2017). This is due, in part, to dogs exhibiting key behavioural characteristics that lead to domestication, such as those related to reduced wariness and low reactivity to humans, new environments, and other external stimuli (Coppinger and Coppinger, 2001, Trut, 1999). This ability to adapt to
human environments has entangled dogs within human society to such a degree that it has made them “vulnerable to any changes that may accompany changes in human society” (Serpell and Barrett, 2017). Thus, our responsibility towards dogs is significant, as they are directly impacted by our actions and attitudes and shaped by changes within our society.

2.1.2 The Evolution of the Human-Canine Partnership

Among the many roles dogs currently have within human society, one of the most influential is that of collaborator, with the Natufian cultures of the Mediterranean, which date back approximately 12,000 years, providing the earliest evidence (Davis and Valla, 1978). The Natufians, being among the first peoples to live in permanently settled villages and thus needing to achieve sustained hunting efficiency, were among the first societies in which human-dog partnerships are believed to be contributing factors to their hunting strategies (Serpell and Barrett, 2017). The increase in human settlements around 8,000 years ago in the area known as the fertile crescent, caused these strategies to shift from wild herd hunting to herd management, requiring settlers to keep animals safe from predators, and result in the first known appearance of livestock protector dogs (Gehring et al., 2010).

In time, these partnerships became cemented throughout the process of domestication, and the influence of humans on the species became increasingly evident. For example, during the breeding practices of the 16th and 17th centuries, dogs were purposefully bred to display specific behaviours that met evolving human needs. Examples range from high performance hunting dogs to lap-warming dogs (Serpell and Barrett, 2017). The 20th century brought with it the mass migration of humans from rural areas into urban centres, and as was the norm “our” purpose-bred dogs came with us. For example, police dogs were first used in 1889 in London, amidst the terror of Jack the Ripper, where officers enlisted bloodhounds to track the elusive killer (Pemberton, 2015). In addition, it was during the London bombing of the First World War when urban search and rescue dogs were first trained to help find survivors (ADI, 2020), and it was also during the First World War when the first assistance dogs came onto the scene, as blinded German soldiers were given seeing guide dogs trained by Dr. Gerhard Stalling near Oldenburg, Germany (IGDF, 2020).
2.1.3 Mobility Assistance Dogs

Nowadays, assistance dogs are classified into 3 types: guide dogs for the blind and visually impaired; hearing dogs for the deaf and hard of hearing; and service dogs for people with disabilities other than those related to vision or hearing (ADI, 2020). The terms assistance dog and service dog are mostly interchangeable, with the latter being mostly used in the United States and former being the term preferred in the United Kingdom; with both terms also referring to dogs that assist people with autism, and people who suffer from seizures, low blood sugar or other psychiatric disabilities (ADI, 2020).

The focus of this research is on mobility assistance dogs, who were first trained in 1975 by Dr. Bonita M. Bergin. Dr. Bergin was inspired to use dogs to assist humans during a trip to Asia where she witnessed donkeys being used by villagers as mobility and balance aids (Bergin, 2012). Upon her return to the US and prompted by the US Individuals with Disabilities Education Act, she began to train dogs to assist disabled students with the first years of training resulting in a string of failed attempts and constant experimentation with different dog breeds, including German Shepherds, Poodles and Dobermans. In time, due mainly to their willingness to work in exchange for food-based rewards and their ability to interact in a delicate manner, the preference for Golden Retrievers and Labrador Retrievers was established (Bergin, 2012).

2.1.3.1 Industry

Founded in 1975 by Dr. Bergin, Canine Companions for Independence (CCI, 2020), was the first charity aimed at training MADs, prompting the development and growth of the industry. In response, by 1986, Assistance Dogs International (ADI - https://www.assistance dogsinternational.org) was founded, and has since been considered the main governing and accrediting body of assistance dog-training programs, overseeing more than 125 training schools across 4 global chapters (ADI, 2020). The non-profit status of ADI members is standard within the industry, allowing them to offset the high cost of breeding and training assistance dogs, with estimates ranging around $USD 50,000 per dog (Cobb et al., 2015). Yet in spite of the large number of training charities, MAD training programs are constantly struggling to meet
the demand; for example, in 2017 - our research partner (§3.1) – the UK based charity Dogs for Good received 4,500 inquiries for assistance dogs while only managing to place 52 (Daniels, 2017).

Due to this over-demand, the industry is in constant pursuit of strategies to increase the number of successful partnerships, for example by focusing on breeding processes aimed at producing dogs with the appropriate temperament for this type of work (Bergin, 2012). However, the dropout rate of these purpose bred dogs during the training programs is still around 50%, which is attributed in part, to behavioural issues exhibited by the dogs, such as dog-to-dog aggression or distraction towards other animals; but also, to the fact that the dogs are not able to adapt to their training and working environments (Coppinger et al., 1998, Serpell and Barrett, 2017, Bergin, 2012, Audrestch et al., 2015), with the latter being a focus of this research.

2.1.3.2 Training

Besides breeding, training dogs is arguably the industry’s most common and influential strategy towards increasing the number of successful partnerships. This is due to MADs being required to perform a series of tasks on behalf of their human partners, which are mostly outside of their natural behaviours and require them to learn specific skills through specialized training (Ramirez, 1999). Specifically, dogs are taught to perform physical tasks which require them to operate and interact with a variety of products and interfaces in diverse environments, which regularly fail to recognize their characteristics as users (Mancini et al., 2016). The combination of extinguishing naturally occurring behaviours and training dogs to perform behaviours in environments that are not designed with them in mind makes training MADs a complex and resource intensive activity, which can seriously impact the dogs’ wellbeing if not conducted correctly (Bergin, 2012).

In order to protect the dogs’ wellbeing during training, nearly all assistance dogs are trained using positive reinforcement techniques, known to be highly effective in shaping canine behaviours through the timely delivery of rewards, usually food-based (Pryor, 2005, Bergin, 2012). Positive reinforcement techniques combine both classical and operant conditioning (Skinner, 2015, Bitterman, 2006, Skinner, 1959) techniques. Based on Pavlov’s experiments with dogs, classical conditioning refers to the association
between stimuli and co-occurring phenomena which Pavlov first measured by recording dogs’ salivary responses when they were presented with food. Then, he started to ring a bell before presenting the dogs with food, which over time, resulted in the dogs’ salivary responses increasing when they heard the bell, confirming that they had learned to associate the sound of the bell with the presentation of the food (Bitterman, 2006). Operant conditioning, studied by B.F. Skinner (1959), consists in the conditioning of a behaviour through timely associations between the behaviour and a reinforcer or consequence. The consequence can either result in a positive or negative reward being presented to the dog which seeks to reinforce the repetition of the behaviour, or in positive or negative punishment which seeks to discourage the behaviour. Hence, positive reinforcement results in something of value being delivered to the dog (e.g. a food reward) which makes the behaviour more likely to continue to reoccur; negative reinforcement results in something being taken away (e.g. pressing down on a dog’s torso forcing them to lay down and then removing the pressure) in order to encourage the behaviour; positive punishment involves adding something that makes the behaviour less likely to occur (e.g. pinching a dog’s ear) to discourage a behaviour; and negative punishment involves something of value being taken away (e.g. not giving the dog attention when they jump on you) in order to discourage the behaviour. To begin with, canine training is usually carried out by delivering positive rewards (e.g. food) simultaneously with a designated marker (e.g. “yes”); over time, this conditions the dog to associate the signal with the reward (classical conditioning) (Bitterman, 2006). The signal is then used to mark a spontaneously occurring or induced desired behaviour. In time, the association between the marker “yes”, followed by the food reward, increases the likelihood that the dog will repeat the desired behaviour (operant conditioning). In this manner, trainers reinforce and shape behaviours that are wanted and suppress those that are not, using the marker and the reward to shape complex behaviours.

2.1.3.3 Role of MADs

The role of an assistance dog is to allow people to achieve an optimal level of functional independence (Audrestch et al., 2015). For MADs specifically, this implies assisting people with mobility related impairments resulting from conditions such as spinal cord injuries, multiple sclerosis, muscular dystrophy, cerebral palsy, polio, and acquired brain
injuries (Sachs-Ericsson et al., 2002, Daniels, 2017). MADs actively assist individuals across a variety of domains that deal with their ability to function at a body (related to movement and bodily functions), activity (related to communication, eating or ambulation), and participation (related to a person’s involvement in life situations such as education, employment and parenting) level (WHO, 2018). For example, in a study by Fairman and Huebner (2001), 202 service dog owners from 40 US states and Canada reported that MADs assisted them with activities such as shopping (76%), cleaning (55%), clothing care (40%), household maintenance (33%), care of others (22%), leaving their home (77%), and using community resources (72.5%). Roth’s (1994) study of 34 disabled recipients of service dogs provided by Canine Companions for Independence reported that their MAD assisted them with activities such as general shopping (69%), grocery shopping (50%), and banking (28.3%). Although mostly focused on enhancing an individual’s mobility and ability to retrieve objects (Sachs-Ericsson et al., 2002), the broad range of assistance provided means that MAD’s have to consistently adapt to and operate within the anthropocentric environments and social settings their human partners are a part of.

2.1.4 MADs at Work and the Challenges They Face

Consider the following scenario for a MAD assisting their human partner, operating an access control as a means to open a motorized store door:

“Mila has impaired mobility and is in a wheelchair. Oso, Mila’s MAD, has his lead wrapped around Mila’s wrist in order for her to be able to have her hands free and propel herself. The door Mila and Oso are approaching is covered in colourful advertisements of the in-store-sales; it seems to be wide enough to allow for Mila to go through comfortably but might be too narrow for Oso to do so by her side. The access button is located on top of a thin metallic vertical post, approximately 80cm high located to the right of the door. The button itself is also metallic with a red inlay that says “open”. Oso usually walks on Mila’s left side, so upon approach Mila must locate the access button and reposition Oso to her right. Mila issues Oso a “push” command to open the door. Oso has to then locate the metallic post and identify the button

1 This scenario although fictional, was based on my direct observations of MADs and their trainers during the studies presented in Chapter 5 of this thesis.
amidst the many posters and graphics. He has to listen for the command in an environment which might contain a range of sounds that are imperceptible to Mila but could make it difficult for Oso to hear. This might result in Mila having to issue an additional gestural cue, which depending on her disability, might or might not be easy for Mila to do. There might also be a range of smells and scents which Mila is not aware of but could impact Oso’s focus and attention and make it difficult for him to locate and operate the button. Oso is a bit on the small side and the button’s height is hard for him to reach, he first tries to push it with his snout but is unsuccessful, missing the button altogether. After another vocal prompt from Mila, he jumps up to push the button with his paw but misses again, possibly due to the small size of the button or because successfully pushing the button’s pad requires a greater pressure than Oso exerted. After a few extra jumps he is able to push the button correctly and activate the door. The door opens towards them, something Mila might have been expecting, but which comes as a surprise for Oso. It requires Mila to move the wheelchair back and alert Oso to reposition again. Mila then moves forward and Oso, as he has been taught, positions himself to the left of the wheelchair; however, because the door turns out to be too narrow, Oso is forcibly made to lag behind and follow.”

Seen from a human perspective, this might not seem like a complicated task, yet when carried out by a canine user, it becomes a very complex interaction. For example, the scenario depicts a particular door, yet not all doors are the same; they vary in their physical characteristics, the placement and design of the access buttons used to operate them, and the direction and timing in which they open and close. Some doors are made of see-through materials, others are opaque or covered in graphics, some are wide enough to allow a wheelchair and a MAD to go through side by side, others are too narrow and require the MAD to lag behind the wheelchair. Some doors have the access button located on the wall next to them, others on a post in front of them; the buttons themselves are of different sizes, shapes, and materials requiring different pressure levels to operate; some doors slide open, while others open towards or away from the user; some remain open for long enough to allow the wheelchair and the MAD to pass through, others do not.

For the canine user, the changes in the environment and the artefacts within it make interacting with devices on behalf of their humans very difficult; requiring them to make
sense of and interact with the different sizes, shapes, colours, and positions they come in. This is in addition to the environmental factors that distract the dog from carrying out tasks, such as sounds, smells, other dogs, or the various details within the environment that could be incorrectly interpreted as relevant. The above variables have the potential of leaving MADs confused and unable to successfully operate devices and fail to assist their human partners.

From a cognitive perspective, this scenario exemplifies some of the challenges presented to the canine user. For example, the reflectivity of the advertisements, or the transparency of the door could cause the MAD to feel insecure (Mancini et al., 2016). Furthermore, the repeated repositioning required during the interaction may cause the dog to lose the context of the task and not understand the purpose of their actions, causing confusion, underperformance and impacting their confidence (Mancini et al., 2016). The repeated jumps needed to push the control, and the consequent loss of balance MADs may experience, could cause them to become frightened of the task until they find a way of balancing on their back legs while they push (Bergin, 2012). The fact that the command “push” also means “up” might also be confusing for the MAD, as it implies the combination of two different actions (pushing and jumping), one to be performed on the target and one to be performed to reach the target (Bergin, 2012). Finally, the unpredictability of the direction in which the door will open, in this case towards the MAD, could also cause further stress for the dog (Serpell and Barrett, 2017). The scenario above illustrates some of the challenges encountered by MADs in their daily work, possibly ignoring some less obvious challenges that remain unnoticed due our species-based-differences; challenges that are exacerbated by the mismatch between the anthropocentric environments they work in and their sensory, physical, and cognitive characteristics as users. Any mismatch that affects MADs overall performance and wellbeing (Bergin, 2012, Mancini C., 2016, Väätäjä et al., 2018, Mancini et al., 2016), and highlights the urgent need to develop interfaces that address these challenges and help create canine-centric solutions for MAD use.

2.1.5 Our Role in Addressing the Challenges Faced by MADs

As dogs have become an integral part of human society, we have bred them to serve us, trained them to carry out work on our behalf and with us, welcomed them into our
homes and developed deep bonds and partnerships with them. Doing so has meant that dogs have had to adapt to our anthropocentric environments, which as exemplified above, often fail to meet their needs. Considering how integral to human society dogs are, how dependent the process of domestication has made them on human practices, and the direct and proactive interactions we require them to engage in (Serpell and Barrett, 2017, Sachs-Ericsson et al., 2002, North, 2016), addressing these circumstances is arguably a key responsibility as part of our role as domesticators, especially when considering the challenges for working dogs, such as MADs.

Throughout history humans have used technology to “create environments that meet their needs, to cross space-temporal boundaries, and to develop large social networks and economies.” (Mancini, 2017b). This evolutionary advantage held by humans is arguably a privileged position to hold and one that, as stated above, should be extended to dogs and to animals in general. The investigation of how technology can help adapt the environment to meet human needs has historically been informed, in part, by disciplines such as interaction design (ID) and human-computer interaction (HCI). As a consequence, when thinking about how to adapt our human-centric environments to meet the needs of animals, it makes sense to build on these disciplines, their aims, values, and methods. The field of ACI (§2.4) extends ID values and methods that aim to: understand the interaction between animals and computing technology; design animal-centred technology to support animals’ welfare and activities, and interspecies relations; and develop methods that enable animals to participate in the design process (Mancini, 2011). It is therefore under the umbrella of the discipline of ACI that this research is carried out, where instead of focusing for example, on canine breeding practices as a means of helping MADs to better adapt to our anthropocentric environments, we address this mismatch between MADs’ characteristics and the environments through the design of tangible technological interfaces that improve their interactions and establish them as legitimate users.

2.2 Interaction Design (ID) & Human Computer Interaction (HCI)

The term ID is commonly attributed to Bill Moggridge and Bill Verplank who in the early 1980’s were looking to develop a field similar to that of industrial design, but focused on software rather than three dimensional objects (Moggridge and Atkinson, 2007).
Since then, the term and the field itself have expanded to include other fields of design, with many practitioners who would have previously described their work as interface, product or interactive system design now describing it as ID (Preece, 2015). Broadly speaking, ID refers to “the design of interactive products (both tangible and virtual) to support the way people communicate and interact in their everyday and working lives” (Preece, 2015). The term HCI was popularized by Card, Newell and Moran in their 1983 book The Psychology of Human–Computer Interaction (Card, 2018) and, similarly to ID, the discipline addresses the design of interactive technology. However it differs from ID in that it has a narrower scope “concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them” (Hewett et al., 1992). Due to the current pace of technological advancement, the shrinking in size of computing systems, and the amount of products that are now considered to be “digital”, the boundaries among these two disciplines can at times be hard to determine (Preece, 2015, Lowgren, 2015, Moggridge and Atkinson, 2007). Most importantly, these fields share a common approach which considers the user an active stakeholder at the center of the design process (Preece, 2015, Lowgren, 2013). The next section presents a comprehensive overview of this approach, commonly referred to as User-centred Design (UCD).

2.2.1 User-Centred Design (UCD)

The origin of the term UCD is commonly attributed to Donald Norman and his research group at the University of California San Diego, where while developing the field of Human Factors in Computer Systems, they emphasized that in order to develop “design principles relevant to building human–machine interfaces, it is necessary to focus on the user of the system” (Norman, 1983). Although focusing on the user is an approach that has its roots in a long design tradition, for the purposes of this research, I focus on the Scandinavian approach to UCD and its influence on the field of computing.

In the 1940’s, the Swedish Hemmens Forskningsinstitut (the Home Research Institute – HFI), studied life within the home, including the use of appliances and other small technological devices. For example, in a study published in 1946, they examined the details of dishwashing, analyzing the activity from a broad range of perspectives including chemistry (e.g. water, and detergents), architecture (e.g. layout of the kitchen),
infrastructure (e.g. format of the sink), and ergonomics. Their intention was to: “... see the different work processes in the home as a whole, where there are a variety of different factors to take into account.” (Göransdotter and Redström, 2018). This outlook on ‘work’ was adopted in the 1960’s and 1970’s by an increasing number of Scandinavian designers questioning the use of products and tools beyond their utility as part of their interest in issues of social justice, since the use of purely utilitarian tools often caused harm to workers (Papanek and Fuller, 1972). As a part of this inquiry and informed by the ideologies of the Social Democratic Parties in 1970’s Scandinavia, the field of Participatory Design (PD) was established. PD aimed to enable products’ intended users to take a direct and active role throughout the design process, to promote consensus among all stakeholders involved, and produce products which would be accessible to a diverse group of users (Bannon et al., 2018). When, in the 1980’s, the use of computer technology became more prevalent, new approaches to design emerged which aimed to produce software and hardware solutions that could be adopted by non-expert users according to their capacities, needs and desires (Norman, 2013). Consequently it became very important to design for and with users, expanding beyond the scope of mere utility into the “holistic experience of use” (Forlizzi and Ford, 2000). Thus, UCD as it is known today, is recognized by the design community as “a broad philosophy and a variety of methods” that are commonly used to describe an approach to “design processes in which end-users influence how a design takes shape” (Abrash et al., 2004) that involves users as active stakeholders throughout the design process (Preece, 2015), and in which the designer acts as a facilitator on behalf of the user to ensure that they are able to make use of the product with minimum effort (Norman, 2013).

2.2.2 Diversity of Users: Usability and Accessibility

However, not all users will be able to influence the design process in the same way. Based on their characteristics, users such as children, adults with disabilities, or older adults, might not be able to participate as actively in the design process, requiring designers to expand their role of facilitators into that of interpreters. Moreover, given the multitude of people currently interacting with technology in their everyday lives, the diversity of user groups has significantly expanded to include users of different ages,
levels of expertise, and cultures (Stephanidis and Salvendy, 1998). This expansion of potential users has informed the concepts of *usability* and *accessibility*. Usability is defined by the International Standards Organization (ISO) as standard number 9241 in the Ergonomics of Human System Interaction (Part 11 1998) as: "The extent to which a product, service, or environment can be used by specific users to achieve specified goals with effectiveness, efficiency and satisfaction in a specific context of use". The goals of usability are further explained in §2.2.4.2. It is relative "to the users’ goals and contexts of use that are appropriate to a particular set of circumstances" (Petrie and Bevan, 2009). Accessibility is defined by the ISO standard 9241-171 (2208b) as: "the usability of a product, service, environment or facility by people with the widest range of capabilities" (ISO, 2008). Based on this definition, usability could be interpreted as a sub-set of accessibility, as the latter would account for usability from the perspective of diverse user groups (Petrie and Bevan, 2009). *Usability* and *accessibility* are concepts which inform UCD approaches that are inclusive in nature such as Design for All2 (most commonly used in Scandinavian countries) or Universal Design3 (most commonly used in the Americas), and which aim to promote "the design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible ... without the need for special adaptation or specialised design" (BSI, 2005). These concepts do not presuppose that it is always possible or appropriate to design products that meet the needs of an entire population; instead they encourage designers to strive to achieve an in-depth understanding of their intended users, and to develop designs that provide the best possible coverage of the population, and that reduce the complexity of use (Luck, 2018). Regardless of what user group they focus on, these

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2 The concept of Design for All was introduced in the Human-Computer Interaction (HCI) literature at the end of the nineties, following a series of research efforts mainly funded by the European Commission. Design for All in HCI is rooted in the fusion of three traditions: (i) user-centred design placing the user at the centre of the interaction design process; (2) accessibility and assistive technologies for disabled people; and (3) Universal Design for physical products and the built environment (LUCK, R. 2018. Inclusive design and making in practice: Bringing bodily experience into closer contact with making. Design Studies, 54, 96-119.)

3 The term Universal Design was coined by the architect Ronald L. Mace to describe the concept of designing all products and the built environment to be both aesthetically pleasing and usable to the greatest extent possible by everyone, regardless of their age, ability, or status in life. Although the scope of the concept has always been broader, its focus has tended to be on the built environment (IMRIE, R. & LUCK, R. 2014. Designing inclusive environments: Rehabilitating the body and the relevance of universal design. Taylor & Francis.)
perspectives highlight the centrality of the user with regards to both the design process and its outcomes. They have also resulted in an abundance of user-centred methods that ACI practitioners can reference, learn from and, in some cases, apply to the design of technology for animals. At the same time, the need to understand animal users from a UCD approach requires ACI practitioners to extend their work beyond the bounds of ID and draw from fields concerned with the study of animals, such as biology, ethology, cognitive psychology, and animal behaviour (Mancini, 2017b).

2.2.3 User Experience (UX)

Usability and accessibility are conceptual foundations of what constitutes a users’ experience when they interact with a product, because if the product is not usable in the first place, a usage experience will not occur. Yet they do not consider other aspects of an experience such as those that have to do with the emotions or affective states experienced by the user when interacting with the product. Albeit not necessarily essential to the product being usable, the user’s affect-based experience is known to influence the interaction in equally important ways. Thus, in order to understand the use of technological products, researchers study how users’ sensory, physical, cognitive, and emotional characteristics shape their experience of use. This is commonly known as UX, a concept initially popularized by Norman (1999) an which has been widely used within the design and computing industries (Law, 2009).

As this field evolved so did our understanding of the different aspects that compose the UX. Yet due to the fact that there is no absolute definition for what an experience is, with scholars referring to a wide range of sources from philosophy (McCarthy et al., 2005), cognitive science (Forlizzi and Ford, 2000), or psychology (Desmet and Hekkert, 2007), there is no unique definition of UX. In order to arrive at a comprehensive understanding of the concept of UX, a focused review of UX definitions suggested by practitioners from various design disciplines was carried out. The various definitions differed in the degree to which they sought to understand the users’ sensory, cognitive, and physiological states, and their influence on the experience, with some highlighting the need to understand the users’ state during the product’s complete lifecycle (Norman, 1998), others only considering the time prior to and during the interaction (Knemeyer, 2015), and others still being limited to the duration of the interaction itself
(ISO, 2015, Hassenzahl and Tractinsky, 2006, Desmet and Hekkert, 2007, Sward and Macarthur, 2007). However, all of the definitions reviewed (ISO, 2015, Norman, 1998, Hassenzahl and Tractinsky, 2006, Desmet and Hekkert, 2007, Sward and Macarthur, 2007, Knemeyer, 2015) promoted the need to understand the users’ needs and preferences in order to inform the designers’ understanding of the UX and provide guidance as to how to measure the quality of the experience. Additionally, they all identified the main components of a UX as: the user(s) who experience the interaction; a product, service or artefact that the user interacts with; and the environment or context in which the interaction takes place. In summary, UX broadly speaking, is a holistic consideration of a users’ task-related and affect-related interactions with products, services and environments, and how the aspects of said interactions meet the users’ needs and shape their experience of use.

2.2.4 The UCD Approach and its Guiding Principles and Goals

A common ID design process comprises the following four activities: establishing requirements, designing alternatives, prototyping and evaluating, with each activity intended to inform one another and to be carried out in an iterative manner (Preece, 2015). Establishing requirements involves understanding the needs an interactive product should satisfy, and how best to go about satisfying those needs when considering the characteristics and context of use of its intended users. Designing alternatives involves creating product concepts that explore diverse ways of meeting the previously defined user requirements. Prototyping involves implementing the design concepts, whether through low-fidelity prototypes that render the basic features of the design, or through high-fidelity prototypes that feel and work almost like the finished product. In order to iteratively define user requirements, it is common for practitioners to generate a large number of design concepts and to explore specific aspects or features of a design during design and prototyping activities by evaluating these directly with their intended users. This type of assessment enables designers to assess the extent to which a design is meeting the user’s requirements and identify the design’s limitations. Depending on the state of the design, this process is repeated until a design which affords the user a good interactive experience is developed (Preece, 2015, OU, 2020, Lowgren, 2015). When carried out under the umbrella of UCD, these
activities focus on the intended users of the design and involve methods which allow them to actively participate in the design process. Furthermore, due to the aim of the design process to afford the users a good UX, both the task- and affect-related aspects of these interactions are important, requiring the use of methods which can help designers understand both. The following sections provide an overview of considerations, approaches and methods relevant to a UCD process aimed at achieving good UX, with some pertaining to the design process as a whole, while others being specific to one of the previously mentioned activities of the design process.

2.2.4.1 Interaction Design Principles

Interaction design principles are the most fundamental set of considerations used by interaction designers to determine if the design produced will meet the users’ requirements and thus afford them a good UX (Preece, 2015). They are abstract concepts intended to help designers to think about the different aspects of their design, and how their implementation might affect the user experience. If a product fails to adhere to said principles, it will not support its intended use and result in a poor UX. The most widely recognized principles are perceivability, consistency, mapping, affordance, feedback and constraints (Mancini et al., 2016, Preece, 2015). “Perceivability, sometimes referred to as visibility, relates to how the elements of an interface are detectable by the sensory capabilities of the user; consistency refers to how the function, organization and appearance of the elements of an interface present regularities and similarities both within its parts and in relation to similar products; mapping, a form of consistency, is defined as the consistency between the presentation of a function on an interface and its outcome; affordance refers to how the form of an interface’s elements suggest the way in which it could be interacted with; feedback refers to how a system lets the user know whether their interaction with it was successful; and constraints refers to where an interface prevents a user from engaging with it in ways that are fruitless (Mancini et al., 2016, Preece, 2015). Each of these principles has a significant body of research behind its conception and application. While this is beyond the scope of this review, here it is important to note how they provide designers with essential considerations to be aware of that can help them establish key usability requirements and assess the degree to which a design meets those requirements.
2.2.4.2 Usability Goals

Usability goals provide interaction designers with a concrete means of assessing various aspects of an interactive product, including determining the extent to which they provide a user with good usability (Preece, 2015). While failing to meet relevant usability goals does not make a product unusable, it does significantly affect its usability and in consequence the UX it affords. The usability goals most widely referred to include *effectiveness, efficiency, safety, learnability, and memorability* (Preece, 2015). *Effectiveness* refers to the extent to which a product enables the user to complete the task for which it was designed; much of *effectiveness* relates to how much support the product provides for the user. *Efficiency* can at times be confused with *effectiveness*; however, from a *usability* perspective the two are quite different, because *efficiency* is about speed and energy expenditure, for example, the number of steps and time the user takes in order to complete a task. *Safety* is the extent to which a system prevents the user from making errors as well as the extent to which it enables the user to recover from any errors made; thus, this is usually referred to as error tolerance. Another aspect of *safety* accounted for within product design has to do with protecting the user from dangerous conditions and undesirable situations (e.g. sharp edges) (Lowgren, 2015). *Learnability* relates to how easy a system is to learn to use; and can be supported by the system leveraging a users’ existing mental models, for example from their experience with similar products or services. *Memorability* is the extent to which a product is easy to remember how to use once the user has learnt to use it. Finally, *utility* relates to the extent to which the product provides the right kind of functionality so that users can do what they need or want to do with it (Preece, 2015, Lowgren, 2015).

While all usability goals are relevant to all interactive products, it may not always be possible or desirable to achieve all goals in equal measure. Thus, in order to have the most impact on usability as a whole, *the goals must be prioritised depending on the activity a product needs to support, the user, and the context of use.* Similar to interaction design principles, usability goals are relevant throughout the design process, informing usability requirements while providing a benchmark against which to evaluate the resulting designs.
2.2.4.3 Experience Goals

Experience goals go beyond usability and address a users’ emotion and affect. They usually relate to satisfaction and include aspects of the UX related to engagement, enjoyment and aesthetics (Preece, 2015, Lowgren, 2015). They are expressed as adjectives by Preece, Rogers and Sharp (2015), including words such as satisfying, enjoyable, helpful, aesthetic, rewarding, and informative. Experience goals are similar to usability goals in that they inform the whole design process, but differ from usability goals because their subjective nature makes it challenging for designers to translate them into specific product features (Hassenzahl and Tractinsky, 2006). However, investigating them, designers are able to construct an idea of the users’ emotions during their interaction with a product and thus gain a holistic understanding of their UX (Forlizzi and Ford, 2000).

2.2.5 Designing for the UX

Understanding which usability and experience goals are relevant to the user and their context of use is paramount to developing a design that affords good UX. Therefore, in order to understand how to meet the relevant goals, designers need to understand the properties of and relationships among the main elements of the interaction (i.e. the user that experiences the interaction; the product, service or artefact that the user interacts with; and the environment or context in which the interaction takes place). In this regard a number of models and frameworks have been proposed. Among these is the human-product interaction model proposed by Hekkert and Schifferstein (2008) (Figure 3). The model systematically describes how the human users’ characteristics (motor system, sensory system, cognitive system and instincts) and capabilities (motor skills, sensitivities, cognitive skills and concerns) are supported by the systems that allow them to interact with the product, or environment and, in turn, how the products’ formal properties (structural properties, materials, composition, technology and labels) acquire meaning (sensory properties, possibilities for behaviour, and functionality) and respond to the users’ support systems.
2.2.5.1 The Evaluative Nature of Designing for the UX

An important aspect to consider when designing for the UX is that in order to determine the number of iterations required to achieve a design that affords good UX there is a repeated iterative loop between designing and evaluating the design (Lowgren, 2015). To this end a wide range of human-centric methods can be applied to assess a design, based on different kinds of data. Some of these include: “checking of conformance to guidelines and standards; evaluations conducted by experts; evaluation with users or potential users; and evaluation of data collected during eSystem\(^4\) usage” (Petrie and Bevan, 2009). Each approach has a series of benefits and challenges and are intended to be carried out by both experts and non-experts. Evaluations based on guidelines and standards can be carried out by non-experts. They provide specific criteria against which to evaluate the design of a system; however, depending on the users’ characteristics and the complexity of the system, systematically going through and evaluating each guideline can make the process time-consuming (Petrie and Bevan, 2009, Grandin and Johnson, 2009). Evaluations conducted by experts rely on task-based evaluations or walkthroughs, reviews and inspections of the design concepts or the design itself. Experts evaluate the products’ adherence to pre-established guidelines, directly interact with the product and provide feedback, or work through scenarios that represent the product to predict the intended users’ interactions (Petrie and Bevan, 2009, Rubin and Chisnell, 2008). However, domain experts are not the intended end users of the technology and may flag issues that are not important for actual users while missing others that actually matter to them. Therefore, expert input must be

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\(^4\) eSystem is understood as interactive electronic products, services and environments.
contextualized to the products’ intended users and their expected context of use. Evaluations based on user testing are probably the most valuable type of assessment available, as they provide direct evidence about the use of the system, including its UX. They can be carried out at various stages throughout the design process and can involve the use of prototypes or final products. However, it is difficult to predict how users will interact with a prototype or product, thus it is important to design user testing and data collection protocols that allow flexibility while still maintaining focus (Petrie and Bevan, 2009). At the same time, researchers need to prioritize what aspects of the UX to evaluate, as users may not be able to test all product’s features depending on its complexity, available time, etc. (Preece, 2015, Rubin and Chisnell, 2008).

Most of the methods described above are associated with written or verbal forms of feedback such as surveys, focus groups or system usage analysis (Petrie and Bevan, 2009). When considered under the focus of this research, most would present obvious challenges when working with animal users; however, in understanding the various approaches to evaluation and the different aspects they focus on, we can better inform the animal-centric design process, and our choice of methods to build upon.

2.3 Ethics in Design Research

Ethics is the philosophical and systematic study of morality, which is concerned with exploring what, for example, makes a good life, how we should live it and how we should treat others. Research-based ethics are commonly categorized into normative ethics - focused on providing frameworks, laws or guidelines that should be followed during research - and applied ethics – focused on providing approaches to reflect on specific issues encountered during research (Frauenberger et al., 2017, Steen, 2015).

Due to technology’s impact on human society and its speed of development, those tasked with researching and designing technological devices are actively confronted with a constantly evolving set of ethical responsibilities (Frauenberger et al., 2017, Sellen et al., 2009). In order to help researchers and designers to consider the ethical implications of their role, the disciplines of design have developed a wide variety of normative and applied ethical approaches to support the process of researching and designing technological devices. Providing an overview of all of these approaches is beyond the scope of this thesis; however, due to these approaches’ focus on UX design,
and their potential for application when designing for and with animal users, the following sections discuss those considered relevant.

2.3.1 Ethical Approaches Developed for UX Design

Most ethical approaches developed for UX design are based on three main frames of reference, those related to professional contexts, those related to broader societal aspects, and those focused on the individual (Steen, 2015). Ethical approaches for professional contexts focus on guidelines relating to fundamental moral positions that provide researchers and institutions with rules to guide the execution of design and protect those affected. For example, guidelines such as those included in the Association for Computing Machinery’s (ACM) Code of Ethics (ACM, 2018). Ethical approaches that consider societal aspects focus on the collective social responsibility of the profession, and often include the consideration of the intent behind developing technology and its effects on the individual and on the broader society (Schinzinger, 2000). Ethical approaches that stem from an individual frame focus on the individual role of the stakeholders involved. For example, the approach of value-sensitive design considers the underlying set of individual values that stakeholders have, and in order to understand their influence on the design process, promotes their clear articulation and transparent discussion (Friedman et al., 2013, Sellen et al., 2009). Other approaches from the discipline of PD, such as situated ethics, consider the role of the designer to include the cultivation of ethical virtues related to the promotion of cooperation, empowerment, and collaborative curiosity and creativity (Steen, 2015).

These three frames of reference serve to provide practitioners with a comprehensive understanding of the many perspectives from which ethical approaches can be developed and considered within the practice of design, which some researchers argue is a practice which in itself is quintessentially ethical (Frauenberger et al., 2017). For the purposes of this research, we focus our attention on approaches that stem from the individual frame of reference, while considering those stemming from broader societal considerations, as they seem to be best suited to the nature of PhD research. Furthermore, we think it important to note that the following sections discuss ethical perspectives in which moral agents are assumed to be human. Discussing the moral agency of animals is beyond the scope of this thesis, however in my role as an ACI
practitioners, I believe that in considering animals as legitimate users it presupposes them to have some agency which is moral in character.

2.3.2 Situated Ethics

Designing technology from a UCD based perspective entails the active involvement of various stakeholders (i.e. users, designers, experts), with each stakeholder considered a moral agent whose participation in decision-making during the design process helps determine the ethical costs and benefits of the technology developed (Frauenberger et al., 2017). Hence, it is in the interest of the disciplines concerned with designing technology to develop approaches that help practitioners consider the ethical acts of stakeholders during the design process. Situated ethics aims to enable stakeholders to "recognise the significance of ethical dimensions in all human interaction." (Frauenberger et al., 2017), and focuses on the dimensions present in design processes where researchers are required to make situated decisions (Munteanu et al., 2015).

The following sections focus on applied ethical approaches, frameworks and considerations developed within the scope of situated ethics that, due to their consideration of situated aspects of empirical research when working with user groups such as children, are considered relevant for this research. In investigating these human-based ethical approaches, our aim is to better prepare ourselves for conducting empirical research with animals which as Mancini (2017b) suggests, involves complex ethical decisions that require negotiating complex situations and circumstances. Normative ethical approaches discussed in §2.5 are also considered, albeit to a lesser degree, due to existing work within ACI having already addressed these (Mancini, 2017a, Vääätäjä, 2014, Hirskyj-Douglas and Read, 2016, Vääätäjä and Pesonen, 2013).

2.3.2.1 Micro-Ethics

Initially developed for application within health care contexts, micro-ethics focuses on the seemingly mundane, yet ethically charged exchanges that occur in every interaction between individuals (Komesaroff, 1995). The approach has since been applied to research within fields such as engineering, computing, and design. To describe the approach, I consider the work of Spiel et al. (2020) presented in the paper: In the details: the micro-ethics of negotiations and in-situ judgements in participatory design with
marginalised children. This work was chosen due to its focus on user groups who share some relevant traits similar to those of dogs, including their vulnerable status as users who, at times, lack verbal capacity; users previously discussed in ACI research by Robinson et al. (2017), and Hirskyj-Douglas et al. (2015). The paper describes two PD projects conducted with disabled (i.e. allistic\(^5\) and autistic) and visually impaired children, during which the researchers are faced with serious ethical dilemmas caused by the challenges that arise when working with this specific user group including: the influence on data collection caused by the difficulty of some children in managing their emotions, the influence of the children’s carers on their behaviour during the research, and the demonstrations of affection of the children towards the carers and researchers. In order to address some of these challenges, the authors propose a framework informed by a micro ethical approach that proposes a “*process of systematically linking situated ethical decisions to the ethical frameworks and range of moral perspectives*” (Spiel et al., 2020) during a design process. This approach is also relevant when designing for and with animals. For example, animals’ behaviour could be somewhat compared to that of children, with regards to expressions of affection or aversion, and their management of emotions during the research. Another example is the potential presence of the animals’ carers and their influence on the research activities. Moreover, the application of micro-ethics might promote the active consideration and reflection on the decisions made by stakeholders on behalf of the animal during the design process, which might promote the formulation of questions such as: “*Where did these decisions stem from?*”; “*What guided the decisions (e.g. personal, group or professional values)?*”; “*Would the animal have made a similar decision?*”; and “*If stakeholders are guided by a specific set of values, are these different from other relevant sets of values and if so, why?*” These kinds of questions enable ACI practitioners to consider the relevance and complexity of the ethical considerations that are involved when working with animals. They can be used to contextualize and assess their decision-making process in order to “*reflect on those choices and discuss them, learn from them and improve our capabilities to make ethically sound judgements in the moment*” (Spiel et al., 2020).

\(^5\) Allistic is defined as someone who does not have autism. LOGSDON-BREAKSTONE, S. N. 2013. Autistic, Allistic, Neurodiverse, and Neurotypical: Say What? Cracked Mirror in Shalott, April, 12.
2.3.2.2 Situational and In-Action Ethics

Situational and in-action ethics are similar approaches, which recognize designers and researchers as active stakeholders during the design process, and which consider ethics to be a “moving target” requiring the application of methods that leave room for adjustment (Frauenberger et al., 2017, Waycott et al., 2015, Munteanu et al., 2015). In-action ethics is in a sense a broader approach compared to situational ethics, in that “it shifts the focus from the situated subject to a deeply interwoven and participatory practice” (Frauenberger et al., 2017). For the purposes of this brief overview, I focused on two papers. The first, Munteanu et al.’s (2015) paper - Situational Ethics: Re-thinking Approaches to Formal Ethics Requirements for Human-Computer Interaction, and the second, Frauenberger et al.’s (2017) paper - In-Action Ethics. In them both authors propose a set of guidelines for mitigating common ethical challenges arising during field research. Some, seem particularly relevant to this research and include Munteanu et al.’s (2015) identification of ethical “triggers”, for example, the potential of the line between research participant and end user being blurred and the adjustment of research protocols based on the assessment of potential ethical risks and participant needs; and Frauenberger et al.’s (2017) reflection-in-action described as the constant and active reflection of researcher actions during the course of the research in order to deal with the “uncertainty, instability and uniqueness” of the ethical dilemmas which might arise, as opposed to focusing on anticipatory planning, and shared responsibility described as the acknowledgement that all stakeholders share the responsibility of ethical reflection during the design process. The above, serve as examples of ethical practices to be fostered during this research, providing clear guidance as to how to approach ethically charged situations which might not have been addressed during the planning of the research. Keeping these in mind will help build reflective practices throughout the course of the research to inform the way in which the design of studies with MADs are conducted and they way to address the sQ3 - “What ethical implications arise when designing interactive canine-centric interfaces?". 
2.4 Animal Computer Interaction: Designing for the Canine UX

The exploration of the interactions between animals and technology is not new, with research such as that of Resner (2001), dating back almost 20 years. Yet many of these early explorations remained fragmented across a variety of disciplines, a circumstance which was addressed by Mancini (2011), who in her seminal article: Animal Computer Interaction (ACI): A Manifesto, called for the systematic development of Animal Computer Interaction as a discipline. Over the last 9 years the discipline has produced a significant body of research focused around the main aims of: i. studying and theorizing the interaction between animals and technology in naturalistic settings; ii. developing user-centred technology to improve animal welfare, support animals in their activities and foster interspecies relationships; and iii. informing the development of user-centred approaches to the design of technology intended for animals, enabling them to participate in the design process as legitimate stakeholders and contributors.

To meet these aims, ACI takes a perspective closely related to perspectives taken by disciplines such as ID and HCI (§2.2), while considering a set of general challenges related to understanding and designing for animal users, which include: the potential inability of technology developed by human designers to truly represent the animals’ interests; the difficulty of designing from the animal perspective when the barriers created by interspecies differences, specifically regarding communication, are so significant; the potential for the animal users’ interests to be in misalignment or competition with those of the designers; and the difficulty for humans of interpreting animals’ interests without any bias (Mancini, 2017).

Hence, designing for the animal UX is, as Mancini notes, “fraught with obstacles and pitfalls” (Mancini, 2017b). Yet despite these challenges, ACI has already produced an important body of research investigating ways to address the above challenges when working with a variety of animals, including dogs, cats, elephants, and fish among others. The following sections provide a chronological review of ACI literature mostly focused on research related to the design of technological devices for dogs, including the approaches taken, the methods applied, and the devices developed. Throughout this review I aim to inform our understanding of the canine UX, and the implications the approaches taken have on designing for and with MADs.
2.4.1 Facilitating Remote Interactions Between Dogs and their Owners

As previously stated, one of the first attempts at developing interactive devices for animals using a UCD approach was Resner’s (2001) Rover@Home, a computer-based application, that aimed to facilitate meaningful remote interactions between dogs and their owners. Resner argued that in order to apply a UCD approach to the design of technological devices for other species, their characteristics and capabilities as users should inform the development of the resulting design. Hence, his work presented a comprehensive review of dogs’ anatomical, sensory, and cognitive characteristics, as well as the design implications these would potentially have for the device. These were then used to define and meet the dogs’ user requirements during the development of the interactive system. For example, when considering the clicking sound the system used to provide feedback to the dogs, which was remotely delivered via a speaker, the author considered the potential implications of the latency in the sound of the click caused by the internet connection speed and its impact on the dogs’ understanding. Because, if the clicking sound was not emitted quickly enough following a successful interaction, there was a risk that the dog would not be able to make the association between their actions and the system’s feedback. This work was also among the first to consider the application of interaction design principles and usability goals towards developing the design of technological devices intended for canine use. However, Resner’s evaluation of the system’s usability was based on feedback provided by human ‘experts’, including the dogs’ owners and certified dog trainers, and not on the dogs’ behavioural responses during the interaction with the device.

2.4.2 Human - Dog Tracking Practices

A more comprehensive approach towards the evaluation of technology used by animals is evidenced in Mancini et al.’s (Mancini et al., 2012) investigation into human-dog tracking practices, specifically those related to the domestic use of dog tracking collars and their influence on human-canine relationships and care-taking practices. The authors carried out a series of in-depth interviews with dog owners who commonly used tracking collars and observed the dogs and their owners while using them. By applying a multispecies ethnographic approach to the research, the team was able to gather and analyse data that gave them insight into the use of tracking collars by human and dogs.
The authors highlighted the importance of the owners’ knowledge of their dogs (e.g. their behaviours and preferences) for understanding the dogs’ UX, while recognizing the need to complement owner ethnographic accounts with the input of animal behaviour experts in order to interpret the dogs’ behaviours from a different perspective. Hence proposing an integrative interspecies semiotic approach to ACI that combined data from various sources including caregivers’ feedback, experts’ assessment, and the animals behaviour in order to evaluate their UX.

2.4.3 Digitally Mediated Human-Animal Interactions

Although focused on cats, the work of Westerlaken and Gualeni (2014) applied a Grounded Theory⁶ approach to evaluating the design of a tablet-based game called Felino. The game featured an aquarium filled with fish and other sea creatures which a cat could ‘catch’ by tapping on them, and was intended to facilitate playful, voluntary and meaningful interactions between cats and humans. To help inform the design of the game, the authors observed and recorded test sessions during which cats and humans played with an early prototype of the game. The footage was later analysed using a software application that allowed the researchers to annotate specific feline behaviours, including those related to rejection, interest or heightened interest. These were then used to determine the cats’ apparent level of enjoyment while playing Felino. By systematically recording when and how much the cats exhibited these behaviours, the researchers were able to assess the cats’ preference for distinct elements of the digital game, such as the speed and type of the sea creatures; and then use these results as input for the next iteration of the design. While the researchers approach allowed them to remove some of their subjectivity when evaluating the animal UX, their focus was on the cats’ general preferences, with no specific reference to specific to usability criteria.

⁶ “In Grounded Theory, rather than performing data analysis starting from hypotheses and preconceptions, the data itself guides the analysis and steers the research in directions that were not planned out from its onset.” WESTERLAKEN, M. & GUALENI, S. Grounded zoomorphism: An evaluation methodology for ACI design. Proceedings of the 2014 Workshops on Advances in Computer Entertainment Conference, 2014. 1-6.
2.4.4 Touchscreens for Canine Use

A more objective and usability-based approach to evaluating animals’ interactions is evidenced in the work of Zeagler et al. (2014, 2016), whose investigation into touchscreen interfaces for dogs, resulted in a set of canine-centric design guidelines. The authors’ hypothesized that the application of HCI methods used to investigate the usability and design of touchscreens for human use would be applicable to the measure of canine interactions. To test their hypothesis, they designed a height-adjustable rig that housed a touchscreen interface on which a series of customizable targets (i.e. different colours, sizes and distances) were displayed. A software program was created to recorded where and when the dog’s came into contact with the screen. By adapting human-centric methods for canines, the researchers were able to identify improvements to the design of the touchscreen that afforded dogs a better UX. For example, by helping them define the size of the targets that seemed to best support dogs’ ability to locate them on the screen. Compared to those of humans’, the dogs’ interactions were less consistent and resulted in more errors, partly due to the screen being inadvertently activated by the dogs’ fur and the distraction caused by the odor left by other participants’ saliva on the screen. Dogs’ temperaments also seemed to affect their performance when interacting with the screen, with more highly driven dogs exhibiting higher motivation during the interaction. Overall, though, the systems’ design responded to the dogs’ characteristics as users and enabled them to accurately and consistently select targets on a screen. The researchers’ systematic application of HCI methods to evaluate dogs’ interactions with technology suggests that it is possible to develop evaluation methods which capitalize on similarities between humans and animals, provided that the latter are able to carry out a similar task to the one assessed. However, by focusing on the evaluation of usability, the researchers did not take into account any experience goals related to the dogs’ interactions with the touchscreen, thus providing limited insight into their UX.

2.4.5 Designing Specialized Technology for Diabetes Alert Dogs

Another application of a multispecies ethnographic approach to data collection was the work of Robinson et al. (2014) in the design of a canine emergency communication system enabling diabetes alert dogs (DADs) to remotely call for help on behalf of their
human companions should these become temporarily incapacitated. The researchers first approach to designing the system involved a market search for similar products. However, because emergency alarm systems are mostly designed with human users in mind, none of the available devices were fit for canine use. Hence, in order to understand the system’s context of use, the researchers partnered with a DAD training charity to conduct a series of multispecies ethnographic studies during which they were able to observe the DADs’ training protocols and partnerships at work. The data collected included direct observations of the canine participants’ spontaneous behaviour, responses to technological artefacts within their training environment, and verbal accounts from the charity’s trainers as well as from the dogs’ human partners. By thematically analyzing the data, the authors defined an initial set of canine and human user requirements with which to inform the design of the system. In order to test a system that would meet the dogs’ requirements, the team produced a series of modular rough and ready prototypes which allowed them to quickly provide the dogs with different design solutions to interact with. For example, the alarm’s trigger could be configured to be activated by three different alternative mechanisms similar to a pull chord switch, a quick release switch, and a quick release magnet. Testing the different configurations enabled the researchers to gain insight into the dogs’ preferred modality of interaction (e.g. tug, pull and detachable), the amount of force necessary to trigger the alarm, the most appropriate form of system feedback, and the system’s shape, size, materials, weight, and location within the context of use. This systematic investigation into the system’s individual features informed the design of a canine alarm that was congruent with the dogs’ characteristics and capabilities as the primary users of the device, while still responding to the human users’ requirements. The focus of this work on representing the dogs’ interests throughout the entirety of the design process is of note; additionally, their application of methods commonly used in HCI, such as rapid physical prototyping, adapted for use with canine participants provides ACI practitioners with a valuable model for future work. However, while the authors reported detailed observations about the way in which the dogs engaged with the early and advanced prototypes, including feedback from the dogs’ human partners and their trainers, they did not systematically measure specific behaviours which might have
contributed to a better understanding the dogs’ more nuanced interactions with the device.

2.4.6 Wearable Interfaces for Working Dogs

The work of Jackson et al. (2015, 2013) focused on the design of wearable sensor systems for working dogs to remotely communicate with their handlers. The systems were developed through the use of eight prototypes through which different system features where iteratively tested with canine participants. Some of the features were designed based on the hypothesis that their consistency with dogs’ naturally occurring behaviours would make them easier for the dogs to use. For example, the design of the system’s sensor-enabled input mechanism was based on behaviours such as biting, tugging, and nose-touching; all common behaviours expressed by dogs to explore their environments. Additionally, the shape of the input devices was based on objects familiar to the dogs, such as “bringsels?” or toys. The different designs enabled the researchers to test the different system configurations, types of sensors (capacitive, proximity, force, and pneumatic), shapes (rectangular and oval), materials (cloth, rubber, PVC), and modes of activation. They also allowed the iterative gathering of detailed canine user requirements related to, for example, the calibration of the sensors’ sensitivity in order to account for the dogs’ different energy levels and their positioning based on breed-specific anatomical differences. All interactions between the dogs and the devices were systematically recorded and quantitatively analysed using a range of metrics to assess the system’s usability. These included metrics such as training time, dog accuracy, sensor accuracy, sensor reachability, overall success, and false-positive rate8 for each sensor. The results provided the researchers with a means to objectively assess the dogs’ interactions with the devices, and to evaluate the extent to which each design was meeting the needs and preferences of the dogs. By developing these types of metrics, this research operationalized an approach to recording dogs’ behavioural patterns when interacting with technological devices, based on formulas specific to

7 Bringsel: a short stick or other device that is suspended from the collar of a trained search dog and used as a signal that a search has been successful “Bringsel.”. Merriam-Webster.com Dictionary. Merriam-Webster.
8 False positive testing was carried out by recording the dogs for 30-minute sessions while performing normal behaviours, such as shaking and sniffing. The dogs were not asked to deliberately activate the sensors during the false-positive testing.
dogs, as opposed to ones developed for humans and adapted for canine use. However, the authors’ focus on the quantitative, usability-based assessment of the dogs’ interactions with the sensors did not account for other important aspects of the dogs’ UX, such as their enjoyment while using the device, their level of satisfaction, or other experience goal-based metrics.

2.4.7 Canine Interfaces for Cancer Detection Dogs

Other research into the design of technological devices based on dogs’ naturally occurring behaviours was conducted by Mancini et al.’s (2015) investigation into cancer detection dogs’ interactions with devices used during cancer detection. Cancer detection dogs commonly work in controlled environments where a set of stands that house both positive and negative cancer samples are lined-up. The stands serve to support a metallic arm at the end of which is a stainless-steel perforated plate, whose underside holds the small plastic containers containing the samples. During detection work the handler issues a command asking the dogs to search each sample; if they find a positive, the dogs are expected to sit in front of the stand that houses the sample. This interaction seems to be quite complex for dogs, as it requires them, for example, to learn to use the sitting gesture as a signal to their handler. If the dog has a delayed reaction to the odor of the positive sample and sits in front of the next stand in the line-up, although their response to the sample is appropriate, they give their handler an incorrect signal. In order to address these challenges, the researchers aimed to provide cancer detection dogs with a more direct signaling system. During the course of the research, the authors’ design focus shifted from a human-centric to a canine-centric design perspective. While early concepts featured keyboards and buttons that the dogs would have to be specifically trained to use for human convenience, the authors’ approach shifted when they realised that they needed to design based on how the dogs spontaneously behaved when coming across odors of interest. Therefore, the design concept the authors prototyped consisted of a height-adjustable stand (so as to suit the heights of different dogs), featuring a pressure sensor under the arm to which the sample was secured, in order to capture the dogs’ interaction with the sample. Hence, while all the dogs had to do was focus on their detection work, the device recorded and visualized each of their pressure readings, enabling the handlers to visually assess the
dog’s response to the samples, and interpret whether a sample was positive, negative or something in between. The device’s new design supported the analysis of the dogs naturally occurring sniffing behaviour as the means to communicate the result of their detection work while eliminating the need for them to “translate their response to an olfactory stimulus into an arbitrary behaviour” (i.e. sitting in front of the stand), and provide the handlers with direct evidence of the result of the dogs’ detection work. Shifting their perspective as the research progressed, the authors’ developed a canine-centric design that leveraged naturally occurring canine behaviours, as opposed to requiring canine users’ adaptation to human-centric behaviours.

2.4.8 Extending Accessibility to Mobility Assistance Dogs

Another important contribution, of singular influence to this research, is the work of Mancini et al. (2016), whose investigation into MADs’ working conditions highlighted the mismatch between the dogs’ characteristics as users and the environments they were commonly required to interact with on behalf of their human partners. Through a series of ethnographic studies conducted with the MADs’ human partners and their trainers, the authors were able to identify a set of user requirements with which to inform the design of canine-friendly access control prototypes. In addition, the design of the prototypes was also informed by the researchers’ explorations and implementation of relevant interaction design principles in conformity with the characteristics of canine users. This approach had been previously considered by Resner (2001) but had not been applied in a systematic manner. The researchers argued that the application of interaction design principles to inform the design of canine-friendly devices would most likely provide dogs with better usability and experience of use. The authors proposed that some of the principles designers refer to in ID had particular relevance to canine-centric design and could be applied according to canine sensory, physical, and cognitive characteristics. Thus, each feature of their prototypes was informed by the implementation of the interaction design principles of perceivingability, consistency, affordance and feedback in conformity of the dogs’ characteristics. For example, the controls were coloured in blue and yellow, colours which are known to be easy for dogs to perceive; they were lightly textured in order to provide better grip during activation; and, when pressed, they produced an audible click which acted as feedback for the
dogs. The authors’ evaluation findings provided evidence that “interactive devices whose design adheres to basic design principles implemented consistently with canine sensory, cognitive and physical characteristics...have the potential to provide better usability and experience for canine users. Conversely, those that fail to adhere to such principles in accord to canine characteristics...are likely to provide poorer usability and experience” (Mancini et al., 2016). This research demonstrates the importance of taking a principled approach to the design of canine interactions. However, the authors’ investigation of the MADs UX was mostly based on the accounts of the dog’s handlers and trainers combined with qualitative observations, rather than on the systematic, quantitative and qualitative observation and analysis of dogs’ behaviours when interacting with the prototypes.

2.4.9 Haptic Vests for Working Dogs

A more systematic approach to the evaluation of the canine UX is evidenced in the work of Byrne et al. (Byrne et al., 2017) and their investigation into the use of haptic vests by working (e.g. rescue, military) dogs in order to support the long range silent, out of voice, or out of sight communication with their human handlers. The system consisted of a vest outfitted with an Arduino Uno microcontroller, a Bluetooth module, a board for controlling a vibration motor, a vibration motor and an operator interface installed on a digital tablet, which enabled the activation of four different vibration intensities. Each component was chosen based on criteria common in the design of haptic interfaces for humans (e.g. users’ skin physiology and sensitivity) in relation to the dogs’ capabilities as users. For example, the choice of attaching the motor directly to the dogs’ fur accounted for their diminished sensitivity to haptic changes due to the structure of their hairy skin, as well as their coat type. To test different motor settings, dogs were fitted with various prototypes and their response was evaluated using a ‘Just Noticeable Difference’ criterion to determine the amount of vibration needed for the dog to perceive a haptic cue. While this type of evaluative method allowed for a comprehensive and systematic assessment of the implications of the dogs’ physical characteristics for the design, its focus remained centered around usability, and did not equally consider the affect-related aspects of the interaction.
2.4.10 Wearability of Biotelemetry Devices

Although carried out with feline participants, the work of Paci et al. (2017) provides a valuable methodological approach for the observation and measure of animal behaviour during their interactions with technological devices. The authors’ investigation into the wearability of biotelemetry devices for animals was informed by the direct observation of the behaviour of 13 cats while these were wearing GPS devices. Their behaviour was recorded according to an ethological observation protocol developed specifically for the study and interpreted using an existing feline ethogram. The protocol identified behaviours that accounted for various aspects of the cats’ experience, including affect-related ones. Hence, quantitative observations (e.g. counts of bouts) and qualitative observations (e.g. critical incidents) of behaviour were recorded and analysed. Ethograms had been previously used in ACI; for example, by Baskin and Zamansky (2015), when observing dogs who were interacting with digital tablets; or by Pons et al. (2015), when assessing cats’ responses during their interaction with robots. However, Paci et al.’s (2017) work provides a more detailed and systematic approach to the combination of quantitative and qualitative ethological observation, providing a comprehensive understanding of the cats’ wearer experience.

2.4.11 Canine Reward Delivery Robot

More recently, the work of Byrne et al. (2019) investigated dogs’ visual and olfactory problem-solving abilities through the design of a system that allowed them to drive a robot through a simple maze. The system consisted of a platform which housed a control panel intended to be used by the dog to control the robot and on which the dog stood to be able to see the maze in front of them. The control panel offered dogs a tug affordance in the form of a flexible stretch sensor built into a standard tug toy, a button affordance in the shape of a yellow momentary button, and a proximity affordance in the form of a box which contained a photocell. The maze was a simple

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9 An ethogram is a list of species-specific behaviours describing the elements and function of each behaviour. They can be described as a species ethogram and an experimental ethogram. The species ethogram is a master list of all known behaviours for the species. Whereas the experimental ethogram is a distillation and reorganization of this list into the behaviours that are relevant to the hypothesis being tested UNIVERSITY, S. 2013. About Ethograms. Available: https://web.stanford.edu/group/compmed/cgi-bin/About%20Ethograms.php.
“I”-shaped course allowing the robot to easily move throughout it and was topped with an acrylic sheet allowing the dogs to see the robot, without being able to access the treat placed atop the robot until they had completed the task of extracting the robot from the maze. The dogs were trained to use the different affordances, whose usability was evaluated based on the dogs’ ease of training and success rate. The research provided preliminary evidence indicating that dogs could learn to operate the different types of affordance and extend their use to novel tasks which require visual problem solving. Although with seemingly little focus on what factors might have affected the dogs’ success rate while activating the robot, the authors’ approach provided the dogs with a very simple design consistent with their characteristics as users is of note, which in its simplicity allowed the dogs to focus on and complete a relatively complex task.

2.5 Ethical Considerations in ACI Research

Ethics as applied to the design for technology for animals is an integral part of ACI’s concerns, with Mancini (2011) first proposing that the discipline’s ethical foundation should be based on a non-speciesist relationship between human researchers and animal participants. In her seminal article, Animal Computer Interaction (ACI): A Manifesto, Mancini (2011) outlined a set of ethical principles related to: preventing any type of discrimination among participants and researchers during the research and design process; protecting all participants from psychological or physiological harm; treating both humans and animals equally during the entirety of the research and design process; considering whether the work being carried out is beneficial and relevant for all participants; affording all participants the ability to withdraw from the research; and enabling informed consent for animal participants. These principles aimed at providing ACI practitioners with guidance as to how to apply a non-speciesist approach to designing for animals, and to establish the discipline on sound ethical considerations; which are of paramount importance when working with all users, especially animals. This work was followed by that of Väätäjä and Personen (2013), who aimed to provide ACI practitioners with set of ethical guidelines based mostly on the 3Rs framework10.

10 The 3R’s framework is historically recognized as one of the most influential frameworks for ethical animal research; and which argues for the replacement, reduction and refinement of animal participants during planning, execution and reporting of animal research RUSSELL, W. M. S. & BURCH, R. L. 1959. The principles of humane experimental technique, Methuen.
the cost-benefit analysis of animal research and an overview of the main concepts within animal welfare. The guidelines were presented in accordance to their potential application to the phases of a research process including the time prior to (justification, legislation, proposal, choice of animal participant, research procedures, use of any aversive devices to handle the animals with during the research, and relevant research personnel training); during (the devices or methods used to identify the animals, the responsibility over the animals, professional handling of the animals, housing of the animals, approval for animal participation, motivation for use of animals, monitoring of animal wellbeing, and discontinuing the research); and when reporting the research (documentation and purpose of the research, animal procurement and housing, research procedures, habituation of the animals during the research, characteristics of the animal participants, and data analysis methods).

The work of Hirskyj-Douglas and Read (2016) also contributed a set of guidelines specifically related to dogs which although providing a review of ethics related literature in ACI, seemed to be missing a foundational core, with some seemingly in conflict with the research approach of ACI. For example, one of the guidelines stated: “avoiding the training of canine participants in the use of technological systems” in order to maintain the focus on the dogs’ ‘true’ needs during their interactions with technology and not those imposed by humans. However, here the researchers seem to disregard that training a dog to use a system does not necessarily have a negative effect on the usability of a system but can provide a novice user with the information needed to have a better UX during the interaction. This is not to imply that all systems designed should need training, but it is not the case that training is always undesirable, whether in the context of eliciting requirements or in the context of learning to use a new interactive product.

In 2017, Mancini (2017a) returned with an expanded ACI research ethics protocol based on a critical review of current legislation regulating the use of animals in research, an overview of ethical implications for animal users, and a focus on welfare-centred ethics. The author continues to support ACI’s non-speciesist approach to research, while including principles of animal welfare as fundamental to the practice of ACI. In her

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11 The potential harm caused to animals during the research as a cost to consider Personen VÄÄTÄJÄ, H. K. & PESONEN, E. K. 2013. Ethical issues and guidelines when conducting HCI studies with animals. CHI’13 Extended Abstracts on Human Factors in Computing Systems.
proposal of a welfare-centred ethics framework for ACI, Mancini recognizes the issue of consent as an essential requirement of participation and addresses it by providing ACI practitioners with the necessary criteria to obtain animals’ mediated and contingent consent to engaging with research procedures. The paper puts forth a series of practical principles for conducting ACI research which “imply but also essentially exceed the welfare and ethics requirements of current regulatory frameworks” and which address aspects such as: respecting and caring for every participant without discrimination; garnering participants’ mediated and contingent consent; doing research that is relevant to participants and consistent with their welfare; avoiding research procedures that may be harmful to participants; and assessing research proposals and obtaining expert support.

2.5.1 Situated Ethics for ACI

The work cited above is fundamental to consider during the course of any ACI research - and possibly any research in which animals are involved - as it provides practitioners with clear guidelines to apply during their investigations into the use of technology by animals, and into conducting research with animals. It underpins the relevance of safeguarding the welfare of animals, not only as an ethical duty of humans, but as an interest to researchers, as the animals’ welfare will most likely affect the research results (Mancini, 2017a). However, most of these guidelines are normative in nature and do not focus on providing guidance on how to address specific circumstances during the work which might not have been accounted for during the planning of the research. Albeit considered by Mancini (2017b) as instances in which designers will have insufficient empirical evidence to decide whether a practice is right or wrong, there is still a need for an applied ethical approach for ACI. Previous research in situated ethics (§2.3) discussed how this approach aimed to address ethical challenges encountered during the course of the research, while providing examples of how such an approach could be relevant to ACI practitioners. However, the actual tools to actively reflect on the ethical implications of their decisions both during the research and as a result of the development of the technology itself, and to clearly articulate their values so as to know how to negotiate and resolve unplanned situations exists. This gap was actively
considered throughout the research and resulted in the proposal of an Ethical Toolkit for ACI Research presented in §9.2 of this thesis.

2.6 Chapter Summary

This chapter provided a review of literature related to themes relevant to this research. It began by providing an overview of the history and evolution of MADs’ within human society and the challenges they currently face when carrying out their jobs, our role as domesticators and its implications on developing technology for animals; and the introduction of the discipline of ACI as the methodological umbrella under which this research is conducted. The next section introduced the disciplines of ID and HCI and the concepts of UCD, usability, accessibility and UX. It provided a description of a common ID design process, followed throughout this research and concluded with an overview of the evaluative nature of designing for the UX. The third section focused on ethical perspectives deemed relevant to this research; specifically, those related to situated ethics, micro-ethics, in-action, and the ethics of care. The fourth section of the chapter provided a chronological overview of relevant ACI literature from Resner’s (2001) argument for the fundamental importance of taking into account the animal users’ characteristics to inform the design of technology intended for animal use, to recent work from Byrne et. al (2019), which exemplifies ways in which researchers can design more complex canine-centred interactions. The final section provided an overview of the ethical guidelines and frameworks put forth in ACI, discussing their main contributions towards framing ethical guidelines for ACI and the need to develop situated ethics for ACI. The research reported in this thesis builds on the existing work presented in this chapter to close an existing gap between the environments MADs work in and their current UX.
3. Research Methods and Approach

This chapter introduces our research partner Dogs for Good (DFG), a UK based assistance dog training charity. It then describes how the main ethical considerations were addressed in the research. It concludes by discussing the overarching methodological approach taken for the research, as well as the methods and approaches chosen for the various studies presented in this thesis.

3.1 Research Setting – Dogs for Good (DFG)

Founded by Frances Hay and first registered as a charity under the name Dogs for the Disabled in 1988, Dogs for Good (DFG) is an innovative dog training charity whose mission is to bring together trained dogs and people in order to help them overcome specific challenges while enriching and improving their lives. Today, they are located in Banbury, UK, at a state-of-the-art training facility where dogs are specially trained as family, community and assistance dogs. The family dog program gives advice and support to help families with autistic children to get the most out of their relationship with their pet dog; community dogs are specially trained to visit adults, schools and care facilities to help people improve their independence, wellbeing and skills, and assistance dogs support adults and children with a range of mobility related disabilities and autism.

The collaboration between The Open University ACI Lab and DFG had been ongoing since 2013. To start this specific research a ‘kick off’ meeting was held at the DFG facilities on November 2017. It was attended by DFG staff Duncan Edwards (Client Manager) and Troy Daniels (Head of Production); Open University staff Dr Clara Mancini (main supervisor), Dr Rachael Luck (second supervisor) and me. During the meeting the initial plan for the research was presented and an outline schedule for the first study. At a subsequent meeting with the same attendees, held on November 2018, an update to the research activities and plans for future research was shared. Among these was the recruitment of MAD partnerships as research participants for future studies, a request

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12 DFG and the ACI Lab at the Open University have been research collaborators since 2013 when, during the ‘More-Than-Human Participatory Research’ project, they both participated in the ‘In Conversation with Dogs’ workshop at the Open University.
which was approved and carried out by DFG on the research’s’ behalf. To initiate recruitment, a letter of invitation to participate in the study was drafted and circulated among DFG’s client list. Once interested partnerships had responded, the ones that best met the recruitment criteria were invited to participate and sent consent forms to fill in and sign (Appendix 1). For each study conducted at DFG facilities or with DFG clients, I provided (and revised, if needed) a detailed study plan, which was approved by Duncan Edwards at least 2 weeks prior to the study.

I acknowledge that, since the studies were conducted with the help of DFG and mostly at their facilities, their influence on who the participants were, and their availability was significant (e.g. MADs actively taking part in training activities). Throughout the past three years, the continuous collaboration with DFG has been very close in terms of assistance, guidance, amount of communication, and resources available to me. Without their help this research would most likely not have happened due to the considerable challenges associated with research participant recruitment and study environments.

3.2 Ethical Considerations and User Consent

This research complied with the research ethics protocol outlined by Mancini (2017a) for ACI practitioners, as well as the Open University’s animal and vulnerable groups ethics regulations, consistent with European and UK legislation on the use of animals in research (Parliament, 2010, UK.gov, 2012). In regard to working with animal participants the research was approved by the Open University’s Human Research Ethics Committee (HREC) for human participants, reference numbers HREC/2016/2303/Mancini1 (Appendix 2), and HREC/2019/3080/Ruge1 (Appendix 3). In order to conduct the research and because MAD partnerships constitute vulnerable populations, I carried out a Disclosure and Barring Service (DBS) check which was approved in March 2019.

Prior to any studies being conducted, all human participants received detailed consent forms outlining the purpose, aims and planned activities of the research. The consent forms highlighted participants’ right to withdraw themselves or any animal participant at any time during the research, asked about their preferred data collection format (e.g. video, voice, or handwritten notes), and described the use and handling of their personal data during the research.
Prior to the research, no incentives were offered to participants, however, after each study had been completed, small boxes of chocolates were given as ‘thank you’ gifts. Additionally, for the studies involving user diaries, tea and biscuits were provided to be consumed during the completion of the study.

Mediated consent (2017a) for MADs’ participation in the studies was obtained from DFG’s client manager Duncan Edwards upon his review of the study plans. Additionally, prior to the studies, mediated consent was also verbally obtained from the dogs’ trainers and/or their human partners. Contingent consent (Mancini, 2017a) from MADs was also sought out during the research, and was based on the ongoing monitoring and discussion with trainers and guardians of any signs of distress exhibited by the dogs during the studies. If any such behaviours were observed the session or trial was immediately stopped and resumed only once the dog was calm and relaxed, thus adjusting the study protocols and incorporating the assessment of potential ethical risk to MAD participants.

In addition, in my aim to gain a deeper understanding of my own ethical positions, assumptions and contradictions, and to critically reflect on the implicit values and biases embedded in my design practice; throughout the research, I consistently recorded reflections of my experience. The accounts were kept in various formats, including handwritten accounts and digital diaries entries which enabled me to link some of the ethical concepts reviewed in Chapter 2 of this thesis (§2.3 and §2.5) with my own experiences. This practice was also used to inform my choice of methods, explained in further detail in the chapters relating to the individual studies; and to inform the development of an Ethical Toolkit for ACI Research presented in §9.2.

3.3 Research Approach

With the aim to design interfaces that respond to MADs characteristics and capabilities as users, a mixed methods approach to the research was adopted. In doing so I was able to capitalize on the exploratory strengths of qualitative methods and the replicability and reliability of quantitative methods to address my main research question rQ - “What kind of interfaces would need to be designed for MADusers in order to provide them with a good UX?”, as well as the supporting questions described in §1.1. Additionally, this approach enabled me to build upon my previous knowledge
of human-centric interaction design methods and adapt them to respond to MADs’ species and breed specific characteristics and capabilities as research participants. My methodological choices were informed by an ongoing consideration of the methods available against the aim of each study, the availability of the participants, the aspects of MADs interactions I wanted to capture and analyse, and the resources available to conduct the research. All methods applied during the research stemmed from the disciplines of ID, product design, PD, ACI and ethology, with the research plan informed and organized around the main activities that characterize a common ID design process as presented in §2.2.4. The following section describes these in more detail, from a general methodological point of view; while the specific applications of the methods and approaches are described in the subsequent chapters of this thesis.

3.3.1 Adapting an ID process for MAD users

3.3.1.1 Understanding the User

In order to understand who their intended users are, interaction designers carry out a series of activities aimed at understanding the characteristics of these user(s) their context(s) of use, and the environments they inhabit (Preece, 2015). Some of these activities, commonly referred to as Phase 0 of the design process (Norman, 2013), are carried out prior to product development and are aimed at helping designers gather information about the user and their characteristics and capabilities. Others are intended to help designers establish specific user requirements in order to inform the design of interactive products that meet and provide the kind of support needed by users (Preece, 2015).

Phase 0 user research was based on a review of current literature related to dogs’ cognitive, sensory, and physical characteristics and capabilities (Chapter 4); and of literature from the field of ACI (§2.4) which reported previous research related to dogs’ use of interactive devices. My understanding of MADs’ current working environments and contexts of use was based on two formative studies (Chapter 5) carried out at DFG. Although user requirements are commonly established during the initial exploratory phase of the design process, in the case of this research, they were gathered throughout the entirety of the design process. This enabled a continuous requirement elicitation
process which allowed me to obtain increasingly specific requirements with which to inform and refine the design of technological devices for their use.

3.3.1.2 Designing Alternatives & Prototyping

The next two phases of the design process, designing alternatives and prototyping, are usually interdependent as one (prototyping) is in a way an expression of the other (designing alternatives). The aim of designing alternatives is to generate a large number of design concepts and possible solutions to meet the users’ needs and preferences; and the aim of prototyping is to enable users to interact with an provide feedback on those solutions (Preece, 2015). Thus, informed by MADs’ user requirements, a range of design concepts were generated. Those which appeared to best meet MADs’ user needs where prototyped to a higher degree of fidelity and tested with MAD and human users. During the course of these activities a variety of concept generation and prototyping methods were used (§3.3.3).

3.3.1.3 Evaluation

In order to define a design's final specifications, prototypes are evaluated to determine which concepts afforded the user the best UX (Preece, 2015), with evaluation taking place throughout the design process. During the course of the research, the main evaluation activities focused on user testing of different prototypes and design concepts by MADs. Specifically, their use of dog-friendly access control prototypes previously developed by Mancini et al. (2016) against standard issue access controls (Chapter 6), low and medium fidelity prototypes of novel early design concepts (Chapter 7), and high fidelity prototypes of the final designs (Chapter 8).

In order to determine the development of the best possible design concept, accurately capturing and interpreting MAD behaviour during their interactions with the various prototypes was of the utmost importance. Thus, in order to inform our understanding of their UX during their use of the devices, in addition to observing their interactions, evaluations conducted by experts (e.g. trainer, MADs’ partners) were also recorded. The following sections provide detailed descriptions of the methods used during the research.
3.3.2 Data Collection Methods

3.3.2.1 Literature Review

The review of literature included papers, books and online resources that helped to define MADs’ user requirements, inform, adapt, and develop methods commonly used in ACI, HCI, ID, and ethology for use with MADs. It also informed the development of the Ethical Toolkit for ACI Research and the Animal Centred Design Framework (ACDF), both presented in Chapter 9.

3.3.2.2 Contextual Inquiry

Contextual inquiry is a common technique used in ID for uncovering user requirements relating to a particular context of use. It follows an apprenticeship model in which the researcher uses a combination of approaches such as direct field observation, interviews, discussion, and reconstruction of past events as a means to ‘learn from’ the users’ subject matter expertise regarding their context of use (Preece, 2015). The apprenticeship model rests on four main principles: context, partnership, interpretation and focus. The principle of context - consistent with the aim of ACI which advocates for research with animal users to be carried out in their naturalistic settings - emphasizes the importance of in situ observations; as it is during interactions with users in their everyday settings that designers are able to gain a first-hand experience of their current context of use, including such things as their habits, work-arounds and usage practices (Preece, 2015). The principle of partnership, also consistent with ACI’s non-speciesist approach to research with animals (Mancini, 2017b), promotes the collaboration between designers and their intended users, with both parties working towards the understanding of the context of use through cooperation as equal partners. The interpretation principle refers to the practice of interpreting users’ behaviours and feedback dependent on the specific context of use in which data was collected, as opposed to the retrospective formation of context-independent conclusions. Due to the richness and quantity of user data which can be collected during the application of contextual inquiry, the focus principle states that the activities related to data collection should remain focused on specific research goals. Many of the approaches applied by researchers during contextual inquiry with human users rely on verbal exchanges; hence it is important to note that, due to the non-verbal nature of MAD users, carrying out
contextual inquiry with canines requires some flexibility in the application of the principles described above. Detailed descriptions of the methods' adaptations are presented in subsequent chapters.

**Direct Field Observations**

Among the methods that form part of contextual inquiry, and which were routinely applied during the course of this research, are direct field observations and semi-structured interviews. Direct field observations allow designers to witness how users behave and use technology within a specific context of use so that nuances which are not elicited through other collection methods (e.g. questionnaires or interviews) can be observed (Preece, 2015). Because direct field observations are being conducted in the users’ naturalistic settings and in a particularly dynamic context, it is important for researchers to respond to any changing circumstances that may arise, while prioritizing the interests of animal research participants and preferably not compromising data collection. In addition, the richness of activities that happen in the field can result in a large amount of data being collected that might be resource-intensive and tedious to analyse, and not be necessarily relevant. Hence, the principle of focus is very important to consider when conducting direct field observations and can at times imply the need to plan out and carefully identify what behaviour is going to be observed. This can be done by focusing one’s attention on basic aspects, such as who is using the technology at any particular time, where they are using it, and what they are doing; and by systematically describing aspects such as the space the observations are occurring in, other stakeholders or artefacts present during the observations, their roles and activities, and the timing and duration of events.

All studies conducted during the research relied on direct observation of MADs’ working environments, including those at DFG facilities, while out training and in their homes. In order to gain a more comprehensive understanding of MADs’ current working environments, activities related to establishing user requirements were kept as direct field observations which were broad in nature. As the research progressed, more detailed frameworks were used to capture specific aspects of MADs’ interactions with technological devices. All direct observations of MADs were video recorded using either an Iphone7, GoPro or GoPro Hero 4 camera. Due to the small size of the cameras and
our use of small tripods, cameras were located in places deemed to be unobtrusive or mounted on boom poles commonly used for lighting and microphone use when overhead views of the interactions were needed.

**Contextual and Semi-structured Interviews**

Contextual and semi-structured interviews can be thought of as “conversations with a purpose” (Preece, 2015), with each type of interview aimed at collecting different types of data. Contextual interviews, also known as unstructured interviews, are exploratory and, although tied to general areas of inquiry, are usually conversations during which a wide variety of subjects are discussed, and during which digressions are common (Kumar, 2012). Semi-structured interviews allow for the use of open-ended questions in a conversational format with inquiry into specific areas of interest, enabling the interviewee to contribute supporting information that could be of future value to the research (Preece, 2015). During the research, we carried out either contextual or semi-structured interviews with all human participants, including DFG employees and trainers, as well as MADs’ human partners. Contextual interviews were carried out while participants were involved in a habitual activity such as training, walking in the park, or driving, and had the purpose of gaining background knowledge about the participants past experience and to discuss general subjects relating to the activity they were carrying out (e.g. training). Due to the ongoing research partnership with DFG, contextual interviews were mostly conducted when meeting new participants, and used as a means to establish rapport. In contrast, semi-structured interviews were conducted in more private settings, including the DFG break and training rooms and in MAD partnership homes. Prior to these interviews, specific questions regarding the relevant areas of inquiry to the specific studies were formulated. Interview data was transcribed into Microsoft Excel or Word files in such a way that the interviewer and interviewee were clearly identified. All interviews were either audio or video recorded using the voice notes feature on an iPhone 7 or with a GoPro or GoPro Hero 4 camera.

Indeed, by applying contextual inquiry to the investigation of MAD users and their interactions with technological devices, and adhering to the principles previously described, I was able to: i. focus the observations of MADs’ interactions in their working environments as they related to the aim of the research questions; ii. interact with MADs
as research partners and legitimate users; iii. gain an understanding of their routines and range of tasks performed on behalf of their human partners, and the challenges doing these presented while in their naturalistic settings; and iv. better interpret and contextualize their observed behaviours.

### 3.3.2.3 Multispecies Ethnography

The practice of ethnography comprises a range of methods traditionally used by researchers to uncover peoples’ social organizations and their activities of work by observing the groups’ dynamics and their communal and/or individual responses to situations. The researcher is tasked with carrying out these observations without imposing any a priori structures or frameworks, while viewing every action as novel and worthy of inquiry. The inquisitive approach of ethnographic inquiry has made its use within the disciplines of design a common practice, as it enables designers to obtain a detailed and nuanced understanding of users’ behaviour that develops as they learn from what the user is doing and what is happening around them (Preece, 2015).

**Ethnographic data collection involves the opportunistic recording of what is commonplace and includes a range of formats, such as, discussions with users, recordings of users’ behaviour or quick sketches or written accounts of particular circumstances.** Additionally, because ethnographic methods depend on observing users’ true behaviours and discussing their honest thoughts, ethnography promotes spending time with users in order to develop a sense of trust between researchers and participants and build rapport, thus, enabling participants to better represent their actual circumstances as opposed to trying to accommodate their behaviours or responses to what they might think the researcher might want to observe or hear. Common techniques include active listening, reframing what participants have said back to them, or enacting something a participant has described (Lowgren, 2015).

The practice of multispecies ethnography is quite similar to the processes described above, but due to the interspecies differences, only the methods which do not rely on verbal exchanges between researchers and participants are applicable. While observation might enable the collection of ‘truer’ data regarding MADs interactions, as opposed to self-reporting, it also requires that researchers are well-equipped to accurately interpret MADs’ behaviour and rely on indigenous knowledge such as that of
the dogs’ trainers and partners (Mancini and Lehtonen, 2018). Ethnological observations of MADs behaviour were carried out during the initial phases of the research and consisted in the recording of their general behaviours when interacting with their trainers, their working environments and the artefacts and devices within them. Additionally, ethological observations of MADs behaviours were also carried out, which unlike ethnological approaches, focus on the definition of specific behavioural categories with which to qualify the observed behaviours and quantitatively measure their occurrence through parameters such as frequency, duration and intensity (Martin et al., 1993). Although data collected from these types of observations are usually statistically analysed this is not always the case, with some ethological observations of animal behaviour being the result of a few critical episodes which when considered against other behaviours, can show a clear effect.

### 3.3.2.4 Critical Incident Technique

The critical incident technique is a systematic approach for obtaining rich qualitative information about significant incidents that happen during user research. When working with humans, critical incidents can be defined either as a result of direct user observation or by asking participants to report critical incidents themselves (Rosala, 2020a). They are defined as a collection of activities that exhibit clear consequences which can be definitely attributed to an effect. The method was originally described by Flanagan (1954), within the research context of psychology as part of the US Aviation Psychology Program during the Second World War. It has since become popular within disciplines such as HCI as it facilitates the gathering of many detailed incidents that help designers to identify critical user requirements derived from particular performances of the studied subject.

### 3.3.2.5 Concept Evaluation Workshop

Concept evaluation workshops are a common technique used in ID to elicit user response and feedback to design concepts, which depending on the stage the concepts are at, are usually facilitated so that any features or details that are lacking in the way the concepts are being presented can be explained (Kumar, 2012). In order to enable participants to provide feedback on their assessment of the concepts, concept
evaluation workshops’ overall format is quite similar to that of a focus group in which participants are given clear goals as to what type of feedback is expected from them, while also allowing free-flowing conversations to occur (Preece, 2015). In the case of this research, a concept evaluation workshop was carried out with DFG staff and used -while relying on the staffs’ expert feedback - to evaluate the initial set of design concepts developed.

3.3.3 Prototyping Techniques

A prototype is a manifestation of a design that allows intended users and other stakeholders to interact with it prior to being a final product or service while providing feedback regarding its design and feasibility (Preece, 2015). Prototypes are usually referred to as low, medium, or high fidelity, where fidelity refers to the level of detail and functionality a prototype provides for intended users. The level of fidelity chosen usually depends on the stage of product development the design is in; where low-fidelity prototypes are commonly used during the initial stages of the process and medium and high-fidelity prototypes are used once the design has been refined to a greater level of detail (Lowgren, 2015). Although prototypes are not required to look, feel, be made of the same materials or provide the same functionality as the finished product, they enable designers to quickly explore alternative designs and ideas in an easy and cost effective manner (Preece, 2015). High-fidelity prototypes usually look and feel more like the final product and provide a higher degree of functionality, allowing designers to provide a more realistic idea of what the final product will look like and receive more robust feedback regarding the overall design or specific features (Preece, 2015). They are usually more expensive to make and use the final colours, materials, and finishes as the final product, or at least features that highly resemble the final design specifications.

To develop the design of a set of smart controls for MAD use, during the course of the research, I developed low, medium and high-fidelity prototypes. For example, during the initial stages of the design development low-fidelity prototypes such as hand-drawn sketches were used to articulate the initial concepts for the controls which depicted a large number of alternatives regarding the mode of interaction, the use of materials and the overall form of the devices. Medium-fidelity prototypes were constructed to test the
size and basic functionality of the design, and high-fidelity prototypes were constructed during the later stages of the research and involved using computer-based models of the design that were then 3D printed and assembled.

3.3.4 Data Analysis Methods

3.3.4.1 Thematic Analysis

Thematic analysis is a qualitative method which focuses on the search and identification of themes and patterns within a dataset that emerge as being important to the description of a particular phenomenon (Fereday and Muir-Cochrane, 2006). When analysing these themes, researchers are able to make inferences regarding the data and formulate theme statements and theory (Neuendorf, 2016). The method is highly flexible in that it can be applied to a variety of research contexts, be used to analyse a wide variety of data (e.g. interviews, focus groups, diaries, literature, and video data), and be guided by different theoretical approaches (Clarke et al., 2015).

Among the most common approaches are those of inductive and deductive thematic analysis. Inductive thematic analysis refers to a ‘bottom-up’ approach to analysis that is grounded in the data whereby themes emerge and are defined based on its examination. Deductive thematic analysis views the data through a pre-existing theoretical lens whereby concepts have already been identified with which to analyse the data. It is a ‘top-down’, structured approach to data analysis which nevertheless requires researchers to remain open to the emergence of unexpected themes that might help them better understand a phenomenon.

During the course of the research both approaches were applied to the analysis of data gathered during the review of literature, the contextual and semi-structured interviews carried out with DFG employees and MADs’ human partners, and when analysing MADs’ and their trainers’ behaviours during our observations of their interactions with technological devices. In regard to the latter, a deductive approach was initially used to catalogue the dogs’ behaviours based on their meaning as defined by the existing literature related to the study of canine communicative behaviours (Handelman, 2012, Bergin, 2012, Serpell and Barrett, 2017); and then grouped into a series of predefined behavioural categories through which a more nuanced and at times inductive understanding of their behaviours was gained.
Due to *inductive thematic analysis* being shaped by the researchers’ background (e.g. their assumptions, disciplinary knowledge and personal standpoints); it is important for researchers’ applying this approach to be vigilant of how and when this might happen. For example, during the course of analysing MADs behaviours, I identified a personal coding bias ([S6.1.2.4](#)) consisted in a tendency to identify a greater number of themes associated with the trainers’ behaviour compared to those of the dogs. To address this bias, I applied a technique commonly used in design research during thematic analysis called the *viewing hats* technique, which consists of researchers adopting different points of view, or *viewing hats*, when coding content in order to help them carry out data analysis from multiple perspectives (Kumar, 2012).

### 3.3.4.2 Ethological Data Analysis

Ethological observations of animal behaviour can be analysed both quantitively and qualitatively as long as they are a result of observing animals’ behaviours in the field according to specific observation protocols. Although no statistical analysis was carried out, during the course of the research a quantitative assessment of MADs behaviour was implemented, specifically during studies aimed at evaluating MADs’ interactions with devices in a more objective and detailed manner. One such instance involved the use of ethograms, which are descriptions of a species’ behavioural repertoire (Martin et al., 1993), and whose use has been previously documented in ACI research; however, to the best of our knowledge it had not been applied towards the investigation of MADs’ interactions with technological devices. In order to analyse MADs’ behaviours, two ethograms were developed, one was related to the measure of MADs’ tail wagging behaviour, and the other was developed during the analysis of MADs’ manifestations of confidence levels during their interactions with the final prototype design.

### 3.3.4.3 Task Descriptions

Task descriptions are a group of methods focused on understanding what users are doing, how they are going about it and what they are trying to achieve in a systematic and comprehensive manner (Preece, 2015). During the course of the research we applied two approaches from this group of methods; task analysis and use cases, with a specific focus on essential use cases.
Task analysis is used to represent the steps a user must take in order to complete a task and is usually represented as a series of graphics that portray and explain the specific actions taken by the user or the system. This systematic depiction of the user’s and system’s actions allows designers to review each task to the level of detail required to assess where additional user support might be needed, where new system features should be added or where unnecessary steps can be eliminated (Lowgren, 2015). There are a few approaches to conducting task analysis, one of the most common being Hierarchical Task Analysis (Preece, 2015). In this approach, a task is broken down into the required subtasks, sub-sub tasks, or sub-sub-sub tasks in order to gain a detailed understanding of the actions that need to happen to complete the task. By applying this method, we were able to gain a detailed understanding of the steps required for a MAD to successfully interact with an access control and identify requirements related to each task and sub task that should inform our design.

Use cases focus on the users’ goals with an emphasis on a user-system interaction rather than on a specific task. They can be represented using graphic diagrams or text-based models in which the interaction between the users or the system is captured (Preece, 2015). Among the various types of use cases, we focused our attention on essential use cases, because they depict the essential aspects of an interaction between the user and the system. The distinction between user actions and system responsibility was very helpful during the development of alternative designs, as it enabled the consideration of the nature of the actions being carried out by MADs and how the design could support these.

### 3.3.5 Evaluative Methods

#### 3.3.5.1 Usability Testing

Usability testing refers to the battery of tests (e.g. experiments, observations, interviews and questionnaires) carried out in controlled or naturalistic settings, whose primary goal is to determine whether an interface is usable by the intended population to carry out the tasks for which it was designed (Preece, 2015). In order to measure the design’s degree of adherence to the relevant usability goals, it involves allowing users to interact with the device being tested while recording for example, the number and kinds of errors users make and the time it takes them to complete a task. It is common practice
to record users’ interactions with the device(s), either through keeping detailed notes of the users’ behaviours, videotaping the test session, or by programing the device to keep track of the ways in which the user interacted with it. Observing users’ reactions while interacting with products provides designers with a rich set of data which helps them understand issues that would potentially have remained unnoticed if only evaluated through written reports or verbal feedback (Preece, 2015). A wide range of usability test methods are available. However, they can be mostly classified depending on the usability goals they are addressing (e.g. safety, effectiveness), the context in which they are carried out (e.g. laboratory, natural settings), the stage the design being tested is at (e.g. early ideation, prototyping), and the methods used to capture the data (e.g. behavioural observations, physiological measures such as heart rate or written surveys or accounts) (Lowgren, 2015).

Usability testing was used to investigate and compare MADs interactions with existing prototypes, devices, and high-fidelity prototypes developed during this research, and the methods developed based on existing human-centric methods adapted for MAD use. The results of these tests allowed us to understand what kind of usability experience the overall design afforded MADs in their current state, as well as to test the impact of specific features on the dogs’ UX.

### 3.3.5.2 Monash Personality Canine Questionnaire Revised (MCPQ-R)

The measuring of canine personality is commonly done by animal welfare practitioners to describe the stable and characteristic behavioural tendencies of adult dogs. It is commonly used as tool to assess a dog’s adaptability, better match dogs who are up for adoption with their future pet partners or provide pet partners with more in depth information about their dogs. For the purposes of this research we were interested in measuring MADs personality as a means to deepen our understanding of them as users, begin to develop a vocabulary for describing canine behavioural characteristics and tendencies, and investigate the influence of MADs’ personality on their UX. The latter due to dog’s personality traits having shown to be highly predictive of future behaviours in dogs (Ley et al.).

Personality is commonly measured using a variety of methods such as by recording and scoring a dog’s behaviour during a battery of tests (Svartberg, 2002); by asking
observers to choose their own vocabulary to interpret the animal’s behaviour (Wemelsfelder et al., 2001); or by asking the dog’s main caretakers to complete canine personality questionnaires on their behalf (Ley et al., 2009a). Since the latter option offers a convenient, time-efficient, cost-effective and comparatively rigorous way to assess personality (Fratkin et al., 2013), for the purposes of this research the proven to be reliable Monash Canine Personality Questionnaire Revised (MCPQ-R) was chosen (Ley et al., 2009a). The MCPQ-R assess the dog’s personality along five dimensions with each associated with specific adjectives as follows: i. extraversion: active, energetic, excitable, hyperactive, lively, restless; ii. motivation: assertive, determined, independent, persevering, tenacious; iii training focus: attentive, biddable, intelligent, obedient, reliable, trainable; iv. amicability: easy going, friendly, non-aggressive, relaxed, sociable; and v. neuroticism: fearful, nervous, submissive, timid. Caregivers are provided a Likert Scale from 1 – really does not describe my dog, to 6 – really describes my dog to score each adjective, that when summed reveal a percentage of the trait exhibited by the dog. Due to not all traits being associated to the same number of adjectives and therefore not having the same maximum score this percentage is related to the maximum score; for example, extraversion is associated with six adjectives and has a maximum score of 36; whereas amicability is associated with five adjectives and has a maximum score of 30.

3.3.5.3 Concept Evaluation Matrix

Concept evaluation matrices enable the representation of two sets of factors of a design which can then be used to systematically assess their relationship, for example, the concept’s features level of adherence to the user’s requirements (Kumar, 2012). This method was used as a means to analyse the data collected during the Concept Evaluation Workshop and helped me identify which concepts should be developed into three-dimensional prototypes. In the end, the results of the concept evaluation matrix did not identify a single design for prototyping, but instead resulted in the identification of a set of features from various designs, which when combined resulted in new concepts.
3.3.5.4 Evaluative Frameworks

Frameworks are commonly used in ID to help designers constrain and scope the UX for which they are designing. Unlike models, a framework does not simplify a phenomenon but instead guides designers as to what to look for. They come in a variety of forms including steps, questions, concepts, challenges, principles, tactics, and dimensions (Preece, 2015). For the purposes of this research, frameworks were frequently used to systematically understand the data collected during the observations of MADs’ interactions with devices, and to structure it in a way that made the output easier to use to inform the development of the design. For example, frameworks were used to evaluate the degree to which the design concepts met the relevant interaction design principles, and to develop the Animal Centered Design Framework in which a set of methods and processes to guide the process of designing for animal users from an animal-centered perspective was proposed (§9.3).

3.3.6 Validity in Mixed Methods

Given the range of methods used throughout the research, triangulation was often used to validate the data collected. Triangulation refers to the analysis of data related to the investigation of an observed phenomenon or data outcome from a minimum of two different perspectives (Jupp, 2006), and is commonly categorized as: i. data triangulation: data that is obtained from two different sources, at different times, in different places, from different people, possibly using different sampling techniques; ii. investigator triangulation: different investigators collect and/or interpret the same set of data; iii. theory triangulation: different theoretical frameworks are used to view the same data or findings; and iv. methodological triangulation: different data gathering techniques are employed to record the same phenomenon.

Data triangulation was used during the studies in which MADs’ interactions with devices were observed and included gathering data from direct observations of the dogs themselves, DFG employees (i.e. trainers and client relations manager), and MADs’ partners. Investigator triangulation was conducted to assess the inter-reliability of codes used to represent MADs’ behaviour by myself and the project’s research fellow, Elizabeth Cox, during the analysis of their interactions with existing access controls. Theory triangulation was applied throughout the research when adapting or formulating
new methods with which to analyse MADs interactions; and methodological triangulation was implemented to gather as wide a variety as possible of data and capture as many nuances as possible of the MAD UX via the application of both usability-based and affect-based analysis methods.

3.10 Chapter Summary

This chapter presented an overview of the methodological approach for the design of technological artefacts for MAD use. It described the researches’ ethical considerations, our research partner DFG, and the multiple qualitative and quantitative based methods used to explore, investigate and understand MADs working environments. These various methods used have been situated within the four basic activities of the design process (eliciting user requirements, designing alternatives, prototyping and evaluation) and identified with direct references to the subsequent parts of this thesis in which they have been described in more detail. The application, adaptation and formulation of these methods was aimed at producing a robust set of data which was used to inform the design and evaluation of a smart control device for MAD use.
Phase 2: Understanding MAD Users
4. Understanding MADs as Users

The literature reviewed in Chapter 2 revealed that despite the significant body of work existing in ACI, the mismatch between the anthropocentric environments MADs work in on behalf of their human partners and the artefacts and devices they routinely interact with has not been resolved. In order to address the mismatch this chapter addresses the first supporting research question (sRQ1 - “In order to design for MADs, what do ACI practitioners need to know about them as users?”), with a focus on investigating MAD users’ characteristics, capabilities, motivations, and behaviours.

4.1 User Research and the Five Human Factors Model

Phase 0 user research is regarded as one of the most important phases of a user-centred design approach as it involves designers investigating users independently of the specific interaction they are designing for, which helps them understand, situate and contextualize the users’ actions, motivations and decisions during the remaining phases of the design process (Mao et al., 2005). A common approach to carry out Phase 0 user research is the Five Human Factors model (Kumar, 2012). The model investigates users’ behaviours as they go about their daily lives by breaking down their UX into five factors. These factors provide designers with a structured and holistic approach to understanding and contextualizing their users’ experience and include:

1. Physical: Relates to the ways in which people physically interact with their environment and with others, including for example what they reach, touch, push, pull, and grab.
2. Cognitive: Focuses on users’ cognitive processes, including the ways in which they associate meaning with the things they interact with and how these inform their decision-making.
3. Social: Considers how users behave in social settings, the kind of interactions they have, and how they collaborate and relate to others.
4. Cultural: Deals with behaviours that help support the creation and manifestation of shared norms, habits, and values.
5. Emotional: Accounts for how users experience their feelings and thoughts, and how they are influenced by the environment.
Due to its comprehensive and systematic approach to understanding human users, the Five Human Factors model was chosen to be adapted for MAD users.

4.2 The Six Factors User Research Model

In order to adapt the Five Human Factors model to MAD users, a series of questions were generated, which when answered, helped me break down, contextualize and better understand the MAD UX. Additionally, this section proposes a sixth sensory factor that accounts for the sensory differences between human researchers and animal users.

1. Physical: How does the animal experience their physical interaction with the environment including with other animals and humans? How do they move? What can they grab and reach? What movements and parts of their body do they use to do so? What is their average size, height and weight? What are their main health issues or concerns?

2. Cognitive: What do we know about the animal’s cognitive capabilities? How do they learn? What kinds of meanings do they associate with the things they interact with, if any? Are they trainable? How do they make decisions? Are there any distinct cognitive differences among individuals, and if so what are they?

3. Social: How does the animal interact with conspecifics, other animals and humans? Is the species known to be social? If so, how are these social groups formed and how do they interact with each other? What is the animal’s role in human society? What is their relationship to humans like? Does the species consistently interact with humans?

4. Cultural: When considering this factor it is important to note that it is assumed to relate to a broad definition of culture, such as “those group-typical behaviour patterns shared by members of a community that rely on socially learned and transmitted information.” (Laland and Hoppitt, 2003). Hence, when applied to animal users, this factor could include questions including: Does the animal and the human(s) they interact with share any common norms or habits? Are these reliant on any socially learned and transmitted information?

5. Emotional: How does the animal commonly express emotion and affective states? What, if anything, is known to trigger or mitigate these emotions (e.g.
artefacts, other animals, humans)? What individual differences, if any, are known to be present in the species when expressing affective states?

In addition to the factors described above, we propose a sixth factor relating to a users’ sensory characteristics to be included in the model; thus, generating a new model called the 6 Factors User Research Model (Figure 4). When investigating users, this 6th sensory factor will help designers be aware of how the sensory differences between them and their intended animal user impacts and influences the way they experience and interact with the world around them. Arguably, the inclusion of this factor would also benefit the human-centric model, as it would help designers address any sensory differences among humans such as those resulting from, for example, deafness, blindness or synaesthesia; consequently, making the model applicable to a wider variety of users.

6. Sensory: How does the animal experience the world, how do they see, hear, feel, taste and smell? How do these characteristics differ from those of humans? How do they differ among different individuals of the species? What senses are the strongest in the species, and is there any evidence of how they use them to interact with and make sense of the world around them?

Figure 4: The Six Factors User Research Model
4.3 Applying the 6 User Factors User Research Model to MAD Users

The following sections provide a comprehensive overview of the literature associated to the application of the 6 User Factors User Research Model to MAD users, with each factor including an initial set of MAD user requirements or considerations. These are of two types, the first relate to MADs as users of interactive devices; and the second relate to MADs as research participants; meaning considerations researchers should have in mind when observing MADs’ behaviours. These are presented throughout the discourse. For a complete set of MAD user requirements see §9.1.

Although most of the literature reviewed is applicable to all dogs; because most MADs are Golden Retrievers and/or Labrador Retrievers, some factors focus on these breeds. Furthermore, the fact that humans and dogs are both mammals means that our underlying physiology is to some extent similar; hence, when relevant, the literature is presented as a comparison between the dogs’ characteristics and capabilities and those of humans. However, the model could arguably apply to other mammalian and non-mammalian animal users as well.

4.3.1 MADs Physical Characteristics and Capabilities

Canines are the species that exhibit the largest degree of variance in shape, size and weight among con specifics (Serpell and Barrett, 2017), with more than 190 registered breeds (AKC, 2020). These breed specific characteristics such as weight and height play a significant role in determining dogs’ physical interactions with other dogs, humans, and their environments. Hence, knowing what breed or breed groups the dogs being designed for belong to, in this case, Labrador Retrievers, Golden Retrievers or a mix of both, will help designers to better understand them as users.

Labrador Retrievers are a result of a cross between Newfoundland dogs and smaller dogs of the now Canadian territory, and were recognized as a breed by the English Kennel Club in 1903 (AKC, 2018b) while Golden Retrievers originated from Scotland, as

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13 The Newfoundland breed of dogs are part of the working group breeds and are known to be gentle, patient, and devoted. They range in height between 28” for males and 26” for females and weigh between 120-150 lbs AKC. 2020. Dog Breeds [Online]. American Kennel Club. Available: https://www.akc.org/dog-breeds/ [Accessed].
a medium sized dog that did well in wild fowling, and were registered in the American Kennel Club in 1925 (AKC, 2018a). The table below contains both breeds’ main physical traits and health concerns as outlined by the American Kennel Club’s breed registry (AKC, 2018b, AKC, 2018a).

<table>
<thead>
<tr>
<th>Labrador Retriever</th>
<th>Golden Retriever</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Physicality</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Height</strong>&lt;sup&gt;14&lt;/sup&gt; (distance from the withers&lt;sup&gt;14&lt;/sup&gt; to the ground)</td>
<td>Males: 22.5” to 24.5”&lt;br&gt;Females: 21.5” to 23.5”&lt;br&gt;Males: 23” to 24”&lt;br&gt;Females: 21.5” to 22.5”&lt;br&gt;Males: 65 to 80 lbs.&lt;br&gt;Females: 55 to 70 lbs.&lt;br&gt;Males: 65 to 75 lbs.&lt;br&gt;Females: 55 to 65 lbs.</td>
</tr>
<tr>
<td><strong>Build</strong></td>
<td>Symmetrical, strong, active and powerful</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Coupling</strong>&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Short&lt;sup&gt;15&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Athleticism</strong></td>
<td>Sound, well balanced conformation</td>
</tr>
<tr>
<td><strong>Movement</strong></td>
<td>Free and effortless, elbows close to body</td>
</tr>
<tr>
<td><strong>Manipulation</strong></td>
<td>Described as “mouthy” meaning that they enjoy chewing, biting, and in general using their mouth to interact with the world&lt;sup&gt;16&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Physical Traits</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Coat</strong></td>
<td>Short, straight, dense and weather resistant&lt;br&gt;Dense, water repellent with good undercoat, straight or wavy</td>
</tr>
<tr>
<td><strong>Tail</strong>&lt;sup&gt;17&lt;/sup&gt;</td>
<td>Otter&lt;sup&gt;17&lt;/sup&gt; Carried with merry action, level or moderate upward curve</td>
</tr>
<tr>
<td><strong>Head</strong>&lt;sup&gt;18&lt;/sup&gt;</td>
<td>Clean cut with broad back skull and a moderate stop&lt;sup&gt;18&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Jaws</strong></td>
<td>Powerful</td>
</tr>
<tr>
<td><strong>Proportions</strong></td>
<td>Shoulder to rump is the same as withers, making them short-coupled. Elbow to ground = ½ withers</td>
</tr>
<tr>
<td><strong>Ears</strong></td>
<td>Close to the head and set far back</td>
</tr>
<tr>
<td><strong>Eyes</strong></td>
<td>Medium size, set deep in sockets and well apart, no white visible when looking ahead.</td>
</tr>
</tbody>
</table>

<sup>14</sup> The ridge between the shoulder blades of an animal, typically the tallest point of the body.<br><sup>15</sup> Coupling in dogs refers to the comparative distance between the last rib and the commencement of the hindquarters. Short coupling refers to the comparative shortness of the distance from withers to hipbones. If excessive, this can restrict a dog’s movement, reach and ability to turn and bend.<br><sup>16</sup> ROBINSON, C. 2017. Animal-Computer Interaction: Designing Specialised Technology with Canine Workers. PhD, The Open University.<br><sup>17</sup> Tails described as otter tails are usually thick at the root, round, and tapering, with the hair parted or divided at the underside.<br><sup>18</sup> The indentation between the eyes where the nasal-bone and skull meet.
<table>
<thead>
<tr>
<th>Neck</th>
<th>Proper length to retrieve game easily</th>
<th>Medium length, merging into shoulders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muzzle</td>
<td>Straight in profile</td>
<td></td>
</tr>
<tr>
<td>Hindquarters</td>
<td>Broad and muscular</td>
<td></td>
</tr>
<tr>
<td>Colours</td>
<td>Yellow, black or chocolate</td>
<td>Rich lustrous golden of various shades</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Main Health Concerns</strong></th>
</tr>
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<tbody>
<tr>
<td><strong>Bones &amp; Joints</strong></td>
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<td></td>
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<td></td>
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<td><strong>Eye Problems</strong></td>
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<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td><strong>Common Injuries</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

| Table 1: Main physical traits and health concerns of Labrador and Golden Retrievers |

Based on the characteristics described in the previous table, the following initial user requirements for MADs are proposed:

- **Due to MADs’ average height**, for devices to be within easy reach, they should be installed at a height between 21.5” - 24.5”.
- **Due to MADs’ average weight**, artefacts that require MADs to stand on them should be able to withstand at least 50lbs, and up to 100lbs of weight.
- **Due to MADs’ powerful build**, devices they interact with should be able to withstand forceful interactions.
- **Although MADs movements are free and effortless**, their shorter **coupling** should be considered during the design of devices that might require highly flexible movements.
- **Due to MADs agility**, they are capable of interacting with devices that require agile movements during their use.
- **Due to MADs preference in using their months to manipulate objects**, devices should either incorporate this form of manipulation in a way that is easy for the MAD to carry out, or consider that the MAD will at some point interact with the device while using their mouths.
• Due to MADs different coat types, any design feature that might require, for example, a haptic interaction should be adapted accordingly.
• Due to the length of MADs tails, design features that might be inadvertently activated by them such as sensors should be considered.
• Due to MADs’ powerful jaws, devices they are meant to interact with using their mouths should be able to withstand forceful bites.
• Due to MADs inclination to dysplasia, joint problems, limber tail syndrome and rupture to their cruciate ligaments, the design of any interactive device should not require the dogs to carry out movements, such as jumping, which might exacerbate these conditions.
• Due to MADs’ predisposition to suffering from vision problems, any interactive device for their use should be easy to perceive.

4.3.2 MADs Cognitive Characteristics and Capabilities

Canine cognition is a vast subject that in recent years has received increased attention due to the growing importance of the human-canine partnership (Serpell and Barrett, 2017). For the purposes of this research the focus is on the aspects of canine cognition that shape MADs capacity to complete their training and to successfully interact with their working environments on behalf of their human partners, specifically, on the cognitive processes of communication, training, and learning.

4.3.2.1 Canine Communication

Overall, although not all canine behaviour has a communicative intent, all canine communication emanates from behaviour (Handelman, 2012), hence, understanding dogs’ behaviour means understanding how dogs communicate with others. Dogs use their bodies as a means to purposefully communicate, exhibiting different postures, movement of distinct body parts, or vocalizations either individually or in combination to communicate a wide range of emotions, states and signals that highly influenced by the stimuli or contextual cues present in their immediate environment, such as noises, smells, or signals received from others (Handelman, 2012). Figure 5 illustrates a few examples of canine communicative behaviours and their meanings. Due to MADs’
interactions mostly requiring them to communicate with humans, the following section provides a brief overview focused on human-dog communication.

Several studies have shown the ability of dogs to interpret slight and seemingly insignificant human gestures, including those that involve changes to our gaze (Hare and Tomasello, 1999) and body movements (Bergin, 2012). Additionally, when exhibited in the presence of humans, behaviours usually expressed among conspecifics can take on different meanings; for example, paw-lifting, nuzzling, or lip licking commonly communicate a state of submission to other dogs, however, when exhibited in the presence of humans, they usually denote attention seeking or appeasement (Serpell and Barrett, 2017). Other studies have evidenced differences in dogs’ communicative tendencies towards humans depending on their breed, with herding breeds appearing to use more eye contact and vocalization, and retriever breeds exhibiting more behaviours which involve body contact (Marshall-Pescini et al., 2016).

Although these considerations do not address all aspects of dog-human-dog communication, they help designers to interpret canine behaviours with a higher degree of accuracy, an aspect that is especially pertinent to this research due to MADs reliance on training to carry out their work.

Based on the characteristics described above, the following initial user requirements for MADs are proposed:

- Due to MADs’ behaviour being highly influenced by the stimuli or contextual cues in their immediate environment - when observing their interactions - researchers should consider any stimuli or contextual cues present in the
immediate research environment and their potential influence on MADs behaviour

- Due to MADs’ using their **bodies as a means to communicate**, the movements required of them to interact with the device should not cause them to communicate any negative or unwanted meaning to either conspecifics or humans.

- Due to MADs **attaching meaning** to seemingly insignificant human gestures (including gazes), researchers should be aware of their own movements, direction of looks, emotional hints, or subtle changes when observing their interactions.

- Due to MADs’ ability to **contextualize their behaviour** to their intended recipient, researchers should consider who the intended recipient was before attaching meaning to MADs behaviours.

- Due to MADs’ **reliance on training**, the design of the device should support clear and accurate human-dog-human communication.

**4.3.2.2 MAD Training and Learning**

Most tasks that MADs carry out on behalf of their human partners are not part of their natural behaviour; instead, they require the dogs to learn specific skills through specialized training most of which is done through the use of positive reinforcement techniques which are reliant on classical - involving the association of an involuntary response to a stimulus; and operant conditioning - involving the association of a voluntary behaviour to a consequence. During training, dogs’ learning curve is quite high, with them being taught upwards of 20 different commands which they are expected to successfully carry out in a wide range of environments (Bergin, 2012). Training is commonly categorized into three learning stages described as: i. acquisition: the dog is introduced and taught a new behaviour or task; ii. generalization: the dog is able to consistently carry out a task or behaviour for a sustained period of time, at a distance from the trainer, in spite of environmental distractions, and in various contexts; and iii. fluency: the dog is able to carry out the task on cue without any additional instruction from the trainer, in a wide variety of situations, and at a success rate of around 80% (Handelman, 2012, Bergin, 2012).
Generalisation and Association

The way in which dogs learn is dependent on factors such as generalization and association. Generalization is the ability of the learner to apply the learnt skill in a variety of contexts and situations, and association is the ability of the learner to perform different behaviours to their corresponding stimuli (Bergin, 2012). In both cases animals are less proficient than humans, in part due to their reliance on perceptual categories as opposed to conceptual ones (Bergin, 2012, Grandin and Johnson, 2009). For example, a human might group the concept of an airplane and an elevator within the same conceptual category because both the plane and elevator have the ability to “go-up”. For dogs this association would be almost impossible to make, unless the inside of the elevator and the inside of the plane had similar characteristics that they could perceive with their senses; for example both having a particular smell (Grandin and Johnson, 2009). In order for dogs to overcome their difficulty with association and generalization and make carrying out the skills required of them easier to learn, trainers make use of specific training protocols. With regard to association, this is done by teaching dogs to perform the desired behaviours in small, concise and individual steps. This incremental approach to learning enables them to develop the correct association between the behaviours they are intended to perform and the varying stimuli. A detailed example of this training protocol is described in §5.2.3.1. The dogs’ inability to generalise is overcome by teaching the same skills in a variety of environments. For example, in thinking of the example described above; in order to teach a dog to “sit” in a plane and an elevator, training would have to happen in both places (Bergin, 2012, Grandin and Johnson, 2009).

Animals’ reliance on perceptual categories also influences their perception of the world around them, with animals paying significantly more attention to detail than humans (Grandin and Johnson, 2009). For example, humans tend to make more inferences about the meaning of the stimuli they perceive, filling in the information gaps through the use of conceptual categories such as the ones previously described. Animals, on the other hand, tend to experience stimuli in the environment without inferring abstract meanings to interpret a situation and fill information gaps by what is actually taking
place (Grandin and Johnson, 2009), making their experience of the world much more specific.

**Confidence**

Another aspect that affects dogs’ learning is their level of confidence while training, which is highly sensitive and can result in the dog experiencing a sense of confusion and a lack of motivation (Bergin, 2012). For example, if a dog continuously fails at a task and is asked to repeat it many times without having made a clear association between the desired behaviour and the reward, they might begin to display stress or avoidance behaviours such as tongue flicking, laying down or looking away (Bergin, 2012). A way to mitigate a dog’s lack of confidence during training is to ensure that they have reached an understanding of the task or behaviour to be performed and why it is required; as it is likely that they will be more successful and enjoy training more (Handelman, 2012). In order to do so, trainers break up the tasks dogs are expected to carry out into smaller subtasks, making sure that the dog has grasped them to a level of understanding where they are confidently performing the desired behaviour. By scaffolding the training in this way trainers establish a virtuous cycle between task understanding and confident performance (Bergin, 2012).

**Rewards**

The accurate use of rewards during training is dependent on the timing and consistency in their delivery, as they are key in enabling dogs to form associations between commands and desired behaviours. For example, when training a dog to sit, if the trainer delivers the reward a few seconds after the dogs’ hindquarters make contact with the floor, the dog might not understand that the desired behaviour is a sit. Instead, by the time the reward is delivered the dog might have performed another behaviour such as laying down or looking in a specific direction, which will result in the dog making an inconsistent and unclear association between the “sit” command and the reward (Bergin, 2012). If this in fact is the case, and the dogs form a mistaken or unclear association, then their learning will be impacted and result in the trainer having to spend more time than initially planned to help them break down the incorrect association and build up the correct one.
Changes During Training

Canine learning is also affected by the changes dogs undergo throughout their training, with one of the most significant being the number changes to their physical and social environments resulting from being in the care of multiple handlers. These disruptions to the dogs’ daily routines have been known to be the cause of behavioural issues and welfare problems which ultimately impact their ability to become MADs (Coppinger et al., 1998). Hence, any continuity to their routines is important for MADs (Bergin, 2012), be it in the form of objects that they commonly use, routines such as outings to specific places, or training protocols and commands.

Most of the factors described above and their influence on a dogs’ ability to learn are commonly addressed through the use of specific training protocols. It is beyond the scope of this thesis to present the entirety of these protocols in detail; however, the protocol for the command “push” is presented in §5.2.3.1 it is important to consider the ways in which the factors might impact the design of technological artefacts.

Based on the characteristics described above, the following initial user requirements for MADs are proposed:

- Due to MADs’ high learning curve during training, when observing their interactions, it is important for the researcher to know what stage of the learning process the MAD is at.
- Due to MADs learning style the design of the device should enable them to learn how to use is through a series of small, simple and individual steps that incrementally teach them how to correctly interact with the device.
- Due to MADs’ difficulty with generalization and association, the design of the device should support them incrementally learning and being trained to interact with it.
- Due MADs’ reliance on perceptual categories, the devices’ features should remain consistent in their appearance and function so as not requiring them to infer any abstract meaning.
- Due to the influence of MADs confidence level on their training, the device’s design should support MADs understanding of the interactions’ tasks and sub tasks.
• Due to MADs reliance on the **timing of the reward** to make accurate associations, the device should support the correct timing of rewards.

• Due to the amount of **changes** that happen **during training**, the devices should be able to, if needed, be installed in the different physical and social environments MADs are exposed to.

### 4.3.3 MADs Social Characteristics and Capabilities

Although a significant amount of research relating to dogs’ social dynamics exists, for the purposes of this research the focus is on investigations into the social structures of companion dogs. Companion dogs exist within multispecies societies in which their interactions with humans can often be more important than those with conspecifics, due in part to the influence humans have on their reproductive success (Serpell and Barrett, 2017). In fact, some scholars question whether companion dogs understand the relationships they have with dogs around them, and consider it more likely that when encountering conspecifics they are responding to a combination of stimuli which they have learnt as a result of human influence on previous encounters, as opposed to a social interaction among conspecifics (Bradshaw et al., 2009).

The above explains the importance of the **socialization** period in a dogs’ life, which begins at about 6 weeks of age and extends until about 24 weeks, as it is during this time that dogs attach meaning to social behaviours with conspecifics (Serpell and Barrett, 2017, Bergin, 2012). Among the many types of behaviours dogs exhibit during this period, one of the most important is play, which is instrumental to their development and, unlike in other species, continues into adulthood (Handelman, 2012). Play in companion dogs manifests itself both as an individual and group activity and is more likely to occur when interacting with another dog or human. It appears to be socially motivated and intrinsically enjoyable (Bradshaw et al., 2015), so it is often used as a reward during training. For example, when training urban search and rescue dogs, volunteers hide from the dog, and once they are found, the dog is given a tug toy to play with. This increases the dogs’ interest in searching for missing humans and helps them associate the task with a positive outcome once they are located (Helton, 2009). Play is also known to increase dogs’ willingness to interact with objects and artefacts (Rooney and Bradshaw, 2002), their successful completion of commands (Rooney and
Cowan, 2011), and to help deepen and maintain the bond with their human partners (Bradshaw et al., 2015). MADs too are offered play as a reward, mostly in the form of free runs or ball chases that are meant to act as opportunities for the dogs to burn off energy and enjoy the time in between training sessions (Bergin, 2012).

Based on the characteristics described above, the following initial user requirement for MADs is proposed:

- Due to MADs’ social behaviours, for the purposes of designing interactions, it might be useful to investigate dogs’ experiences during their socialization period, their attitudes towards play, their current context(s) of use, and the roles of their human handlers.

### 4.3.4 MADs Emotional Characteristics and Capabilities

Animal emotions have been a subject of heated debate ever since the notion was first described. This section does not aim to advance this debate. It does however aim to investigate MADs’ emotional states during their interactions with technological devices as a means to inform their design. To avoid the pitfall of anthropomorphising the emotional states of animals, I shall endeavour not to attribute human emotions to animals, but rather to identify canine communicative behaviours known to express affective states and describe them through the use of human language. Therefore, this section engages with similar themes to §4.3.2.1 Canine Communication, with the difference that here I focus on the review of literature that concerns specifically the types of behaviours dogs use to express affective states, such as fear, arousal, stress, and joy (Handelman, 2012).

The expression of fear in dogs usually relates to behaviours that exhibit states of submission, flight, or fight. If submissive behaviours are not effective or the ability to flee the situation is not possible, the dog will most likely respond with threats or an attack towards other dogs, humans, or the environmental stimulus that triggered the reaction (Handelman, 2012). Behaviours associated with fear include freezing, fidgeting, fleeing, fighting, and fear displays such as crouching, ears pinned to the back of the head or pinched, tail being tucked between legs, barks, and growls (Handelman, 2012). Arousal is broadly defined as a “general state of readiness to respond to the environment which can be both pleasurable and distressing depending on the context.
“in which it happens” (Handelman, 2012). It is needed as a means to direct an animals’ attention, and, like many other aspects of physiology in mammals, is regulated by mechanisms, such as the limbic functions of the brain (Handelman, 2012). Different states of arousal in dogs are needed for learning and social play to occur, however, when arousal is born out of distress it can lead to dogs’ ‘spiralling out of control’ and to display behaviours such as a heightened blinking, tongue flicking, and respiration rate, piloerection, flared whiskers, anal display, penis crowning, barking, whining, and other vocalizations (Handelman, 2012). When arousal is pleasurable, also referred to as eustress, it is an expression of attention or anticipation and is usually exhibited in behaviours such as perked ears, tail wagging, and upright posture (Bergin, 2012).

Stress is highly influenced by a dogs’ past experience and thus, varies among individuals. Different dogs might have opposing reactions to the same situation, for example some dogs might enjoy riding in a car, while others might develop a deep aversion to doing so (Handelman, 2012). A dog can very quickly change between a state of eustress to distress, with both states sharing some of the same exhibited behaviours and neurochemical changes in the brain (Handelman, 2012). Hence, in order to actively interpret the type of stress the dog is experiencing, the context in which the behaviour is occurring and how the elements within it are affecting the dog are of major importance.

Joy is related to pleasurable experiences and is usually expressed as a combination of behaviours that denote comfort, safety and enjoyment including for example running in a horse style gait, playing, and rolling (Handelman, 2012). Joyful expressions are common amongst all dogs, yet studies have shown joy to be associated with different preferences among individual dogs. For example, some dogs seem to show a preference for playing with toys over that of engaging with humans or vice versa; with both activities leading to the expression of joyful states (Serpell and Barrett, 2017).

Based on the above descriptions of dog’s main affective states, it is clear that the behaviours known to express these states need to be contextualised to the time and place where they happen. For example, if crying, whimpering, or whining is observed during the course research activities involving dogs, it is important to note that this behaviour can convey fear, frustration, loneliness, seeking of care-giving and/or attention associated with specific elements of the research context (Handelman, 2012).
In other words, when observing MADs interactions, it is important to consider the expression of their emotional states as directly related to the contexts and times during which they occur. Moreover, a dogs’ individual traits and characteristics should also be considered, as dogs might differ in their behavioural responses to the same stimuli. Based on the characteristics described above, the following initial user requirement for MADs is proposed:

- Due to MADs’ reliance on arousal as a means to direct their attention, the type of arousal interacting with a device should promote should be pleasurable in nature.

### 4.3.5 MADs Cultural Characteristics and Capabilities

When examining MADs’ cultural characteristics, most concern how MADs interact with and what their role is in human society. However, other factors such as shared norms or habits have not yet been discussed. To do so, literature that investigated the relationships between MADs and their human partners was reviewed. Mostly, existing research focuses on examining the impact that having an assistance dog has on humans, while emphasizing the importance of the human-animal bond. The **human-animal bond** is broadly defined as the bond that forms between humans and animals and which is supported by the elements of safety, kinship, constancy, and intimacy (Katcher and Beck, 1983). In contrast to other human-animal bonds, the human-canine bond has shown to be similar to that of bonds that are created in human-to-human relations (Bonas, McNicholas, and Collis; 2000). Moreover, the relationships between assistance dogs and their human partners are considered to be stronger and more complex than those with companion dogs (Audrestch et al., 2015), a claim that is supported by evidence of a heightened degree of interdependence between assistance dogs and their humans. The relationships between MADs-to-humans and human-to-human seem to share significant commonalities, especially in regard to the strength of the attachment that is formed. Hence, investigating attachment theory and its main elements as a means to better understand and identify any shared norms or behaviours that occur between MADs and their partners seems to be pertinent.

Attachment theory pre-supposes that infants belonging to the mammalian species are born with a behavioural system that allows them to remain safe from danger by
regulating their proximity to a caregiver while exploring their environment (Kwong and Bartholomew, 2011). These types of attachments are evidenced throughout the literature related to MAD partnerships. For example, Lane et al. (Lane et al., 1998) found that the majority of children and adults who were part of a MAD partnership reported a close, affectionate and comforting relationship with their dog that extended beyond a working relationship; with many study participants stating their dog was “at least as important as a friend or companion rather than just a working dog” (Lane et al., 1998). Additionally, Kwong et al. (2011) reported feedback from a human partner who described their relationship with their MAD in the following manner “Once you live with an animal that long, it’s almost like a man and a woman, you know, when you’re living in a relationship and it’s a good relationship, you know that the other person being there is a comfort and you, lots of times you don’t even have to say anything. Just have to know that that person is there.” These studies evidence the existence of behaviours which could arguably be considered the basis of MADs culture and consist in a set of shared norms and habits between the parties that include behaviours such as set routines or activities including petting, cuddling, kissing, and gazing at each other.

Based on the characteristics described above, the following initial user requirement for MADs is proposed:

- Due to type of bond that develops between MADs and their human partners, their interactions with the device should promote behaviours that are in accordance with the relationship.

4.3.6 MADs Sensory Characteristics and Capabilities

4.3.6.1 Audition and Vocalisation

Auditory perception is the ability to perceive sounds by detecting vibrations and involves aspects such as the shape and size of the auditory organ, the range in the frequency of vibrations detected, and the capacity to differentiate sounds (Wever, 2017). Some dog breeds, such as German Shepherds, can independently swivel their ears up to 180° degrees, providing them with the ability to direct one ear towards a specific sound, and then have the other one follow (Helton, 2009). Breeds with erect ears use them as amplifiers for incoming sounds, and usually have a superior hearing ability than breeds with floppy ears (Heffner, 1983). Labrador and Golden Retrievers
both have floppy ears; however, they also move their ears in ways which facilitates their capacity to accurately scan their environment, capture, and pinpoint sound direction (Serpell and Barrett, 2017), and attend to different aspects of sound such as location and quality (Heffner, 1983). Dogs have a greater auditory range than humans, with dogs’ hearing ranging between 67Hz and 41,000–47,000Hz, and functioning best between 200-15,000Hz; while humans’ hearing ranges between 13-20Hz and 16,000-20,000Hz, and functioning best between 1,000-4,000Hz (Heffner, 1983).

In terms of vocalization, dogs generate a variety of sounds including baying, barking, crying, chuffing, howling, huffing, whining, yelping, whimpering, and growling. Depending on their frequency, volume and duration, these sounds are mostly used as communication signals (Cohen and Fox, 1976). For example, a quick and continuous single bark without any variation in tone, volume or cadence usually communicates a “go away!” message; while barking that has variations in tone, volume and cadence, and that is accompanied with a growl or a huff usually conveys a warning or threat (Handelman, 2012).

4.3.6.2 Vision

Vision comprises several distinct aspects such as the ability to perceive light, visual perspective, visual acuity, motion, and colour vision (Ford, 2014). In a general sense dogs - like humans - are visual generalists being able to see during the day and night; and within a broad range of light levels (Serpell and Barrett, 2017). However, dogs are about four to five times more sensitive to low light than humans with their ability to perceive light described as scotopic, meaning that they are adapted to dim lighting conditions (Byosiere et al., 2018). Another aspect to consider is the rhodopsin photobleaching effect when moving between well-lit and dark environments; as it takes dogs twice as long to adapt to the change in lighting conditions as it does in humans (Byosiere et al., 2018).
When it comes to visual perspective, a dog’s field of vision is directly related to their breed, size, height, location of their eyes, and their overall facial bone structure (Ford, 2014). Most dogs have an average field of vision of 240°, against a human field of 180° (Ford, 2014), allowing dogs to better scan the horizon. Dogs can focus on objects within 50-33cm of their eyes, but closer objects appear blurred to them (Miller and Murphy, 1995). Dogs and humans both have binocular vision which enables them to perceive depth and distance (Beaver, 1999). When it comes to motion sensitivity, dogs outperform humans, being able to perceive moving objects at a distance of 810m to 900m, and stationary ones at 585 meters (Beaver, 1999, Miller and Murphy, 1995). In terms of colour vision, dogs are dichromatic, meaning they only have 2 types of cone photoreceptors (blue and yellow) as opposed to the 3 present in humans (blue, red and yellow), making reds and greens harder to detect (Miller and Murphy, 1995). Hence, dogs see the world in hues of yellow, blue and brown, unlike the human’s richer spectrum (Figure 6).

![Figure 6: Differences between human (left) and canine (right) vision](image)

4.3.6.3 Olfaction

Olfaction is composed of 2 basic processes; the first is dependent on what are called olfactory receptors (OR), which capture chemical signals in the form of odorant molecules; and the second, is the conversion of these into electrical signals that are then transmitted to the brain (Quignon et al., 2012). Unlike our understanding of human neurological scent interpretations, our knowledge of olfaction in dogs is currently limited to what happens in the nose, meaning the OR receptors (Galibert et al., 2016). Nevertheless, we know that one eighth of dogs’ brain is devoted to processing scent, surpassing the human sense of smell by up to 50 times (Syrotuck, 1972). This means that
dogs experience scent-rich worlds, which are challenging for humans to relate to. As Horowitz (Horowitz et al., 2013) states, “as humans see the world, dogs smell it”, an ability which could explain the continuous evolution of canine-human scent-based partnerships, with the most recent ones being those between humans and drug and explosives-detection dogs (Gazit and Terkel, 2003), cancer detection dogs (Johnston-Wilder et al., 2015), low blood sugar detection dogs (ADI, 2020), and scat detection dogs supporting wildlife conservation efforts (Orkin et al., 2016).

4.3.6.4 Taste

Most research in canine taste has been the result of 2-choice food preference tests, identifying the strongest preferences to be for meat and sugar (Houpt and Smith, 1981). However, because taste is highly affected by odour and texture, it alone may not be responsible for food preference. Other research has investigated preferences that take into account different materials and textures in objects meant for dogs to interact with using their mouths and/or snouts (Robinson et al., 2014, Jackson et al., 2015). However, much remains to be understood about the canine sense of taste, which could help understand their interaction with the world, because - to echo Horowitz’s (2013) previous comment – “where humans use their hands, dogs mostly use their mouths and snouts.”

4.3.6.5 Touch

Very little is known about the canine sense of touch, due to dogs mostly being covered in hair or fur. This means that dogs’ skin has a thinner epidermis than the hairless skin of humans, and a simpler dermal-epidermal layer (Miller Jr et al., 2012). These differences in thickness and structure of the skin affect both sensitivity and nerve resolution, changing how dogs experience and respond to stimuli such as pain, pressure, tension, temperature, texture, weight, contours and vibrations (Byrne et al., 2017). In addition, dogs hair and fur is not uniform, with seven different phenotypes of coat length and texture, and two types of coat densities (Cadieu et al., 2009), making understanding canine touch even more complex. However, touch is important to dogs, and a fundamental part of the human-dog relationship. For example, when puppies have yet to open their eyes and ears, it is through licking and touch that their mothers
communicate with them (Serpell and Barrett, 2017). Dogs touch each other during play, engaging in touch-related activities such as nudges, body to body contact, and playful biting (Handelman, 2012). Dogs and humans also communicate through touch, including activities which have shown to be enjoyable and beneficial to both, such as petting and scratching (Charnetski et al., 2004, Feuerbacher and Wynne, 2015).

4.4 MAD User Requirements

Based on the characteristics described above, the following initial user requirements for MADs are proposed:

- **Due to MADs auditory capabilities**, the devices’ audio-based features should be adapted for a range in which either dogs or both humans and dogs can perceive, and be in the range of 200 - 4,000Hz.

- **Due to MADs visual capabilities**, the devices’ colour, shape and size should be adapted for a user that is somewhat far sighted, sees best in the blue-yellow colour range and is perceivable at a distance of approximately 500m.

- **Due to MADs olfactory capabilities**, the devices’ scent-based features, should be perceivable and pleasurable to the dog. However, due to our lack of understanding of what scent actually means for a dog, this requirement although in principle one which should be explored, makes its application during this research highly unreliable. For example, if we wanted to apply a scent-based cue for the activation of a device, what scent would we use? A scent close to that of food might instigate the dogs to come into contact with the device. But then we would inadvertently cause them frustration for not being able to find the source of the odour? Hence, in as much as our knowledge of how dogs perceive odours and extract information from them remains to be understood; its integration into design seems to be not quite mature enough to consider.

- **Due to MADs’ taste-based capabilities**, the devices’ features that are expected to be interacted with while using their mouths, should consider the implications of how these might taste to the dog.

- **Due to MADs’ touch-based capabilities**, the devices’ features should ensure that the interaction is pleasurable or at least neutral for a dog, independent of what extremity (e.g. paw or snout) they use to touch the device.
4.5 Chapter Summary

This chapter provided an overview of the importance of understanding a design’s intended users prior to beginning the design process. It introduced the Five Human Factors Model for investigating the aspects that shape users’ lives, decisions, and motivations; including their physical, cognitive, social, cultural, and emotional characteristics. An adaptation of the model for use with MADs - The Six Factors User Research Model – was proposed, featuring the addition of a sixth sensory lens to help address the related differences between human researchers and animal users. The structure of the model was then used to describe MADs user characteristics and capabilities, including the formulation of an initial set of user MAD requirements and/or considerations.
5. The MAD User Journey & The Advanced Training Stage (ATS)

This chapter reports on two studies that aimed at addressing the second supporting research question srQ2 - “In order to design for MADs, what do ACI practitioners need to know about them as users?” - by investigating MADs current contexts of use, including the stakeholders, tools and artefacts they interact with, the environments they work in, and the training and types of assistance MADs’ carry out on behalf of their human partners.

5.1 Study 1: The MAD User Journey

The aim of this study was to investigate the journey dogs experience during the process of becoming MADs. Results help construct MAD and human user journeys which revealed a rich and complex ecosystem of supporting human stakeholders, activities, environments, and artefacts. The following sections describe the study activities in more detail.

5.1.2 Participants

Participants in the study included 2 MADs, a three-year-old female black Labrador-Golden Retriever mix and a 21-month-old male Golden Retriever; both in their last weeks of training. Additionally, 14 DFG staff, who belonged to the following teams, responsible for process related to:

- **Puppy Supply**: Breeding, brood and sire matching, fertilization, birthing, and puppy whelping.
- **Health & Wellness**: Monitoring and providing oversight relating to the dogs’ development and veterinary care.
- **Training**: Training protocols, skills development, activities and assessments.

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19 Broods and sires are terms commonly used to describe the female (brood) and male (sire) dogs used as puppy breeders.
20 Whelping is the term used to describe the first few weeks of a puppy’s life when they are left with their mother and during which they open their eyes and ears, nurse and begin to socialize among their litter.
• **Puppy Support**: Monitoring the dogs’ development while in the care of Puppy Raiser Volunteers (volunteers who board and care for the dogs during their first eighteen months) and Training Volunteers (volunteers who board and care for the dogs during their 16 weeks of training).

• **Client Services**: Providing support to potential clients during the application process and overseeing the matching process of MADs and clients.

• **Aftercare**: Providing support to MAD partnerships from the time they are matched, to when the MADs are retired.

### 5.1.2 Methodology

The study took place over a five-day period (Monday December 4th to Friday December 8th, 2017) at the headquarters of DFG during which, to have more direct access to the research participants it was arranged for me to stay in one of DFG’s in-house suites. In preparation, interview protocols were developed containing questions regarding the staffs’ background, previous work experience, their role and responsibilities at DFG, and their everyday working practices with MAD partnerships ([Appendix 4](#)).

During this time, I observed and recorded ten MAD training sessions which took place in various training environments including a quiet residential area, the home of a Training Volunteer, a park, a town high street, a shopping mall, and DFG headquarters. Data was also collected through a series of four contextual, and six semi-structured interviews carried out with staff belonging to the Puppy Supply, Puppy Support, Training, Aftercare, Training, and Health & Wellness teams. In addition, daily entries of any critical incidents observed were digitally recorded. Interview and critical incident data was first analysed using an initial set of codes based on the areas of inquiry included in the interview protocols; however, some of the participants’ responses did not fall into any of the pre-defined codes, thus, an inductive data analysis approach was implemented, and a series of emergent codes were added to the initial code list ([Appendix 5](#)). This revealed two distinct content themes, the first labeled Human-Canine Processes was related to content which described DFG processes and procedures in which DFG staff directly interacted with the dogs; and the second Human Processes was related to content which described DFG’s internal processes and procedures.
5.1.2.1 MAD and Human User Journeys

Both content themes were used to populate user journey frameworks, which are tools commonly used within ethnographic research designed to visually represent the relationships in time between the elements (users, environments, artefacts, and activities) of a users’ context of use (Preece, 2015, Kumar, 2012). Human-Canine Processes were used to populate MADs’ 11-year journey from the time they are born to the time when they are normally retired, and Human Processes were used to populate the human user journey, capturing the main activities carried out by DFG staff, volunteers and clients in support of the dogs. A snapshot of MADs’ user journey during their first weeks of life is illustrated in Figure 7.

The user journeys produced a comprehensive chronology of both MAD and human users’ working conditions and activities, their relationships with each other, and allowed the identification of six MAD development stages described in §5.1.3.
5.1.2.2 Dynamic Clustering of the Data

In order to fully investigate content belonging to the Human-Canine Processes theme, it was further analysed using dynamic clustering techniques, which are a method of coding commonly used in design research to review large amounts of content related to user behaviour (Kumar, 2012). In order to allow for the quick visual identification of the content, single data points each accompanied by a quick sketch that depicts the data point are transcribed onto individual Post-It ® notes. The notes are then adhered to a large surface where they are moved, arranged and rearranged into clusters that reveal both obvious and non-obvious associations (Kumar, 2012). The Post-It ® notes describing critical incidents were positioned alongside and atop the user journeys, and clustered based on the human stakeholder engaging with the dogs, including DFG staff, volunteers, or clients. In doing so, the degree and type of influence the different human stakeholders had on the MADs quality of experience was evidenced. Then the Post-It ® notes were rearranged (Figure 8), based on MADs’ use of tangible interfaces such as the training tools or devices they commonly interacted with throughout their journey, allowing me to identify the different types of interfaces MADs commonly interact with.

5.1.3 Findings

In investigating MADs current working environments, a set of human and canine focused user journey frameworks were developed, which provided a detailed understanding of
the training MADs undergo in order to be able to assist their human partners, and the types of interfaces they commonly interact with. In addition, the recorded observations provided an initial understanding of how the human stakeholders, the environments, and the artefacts and interfaces MADs interact with during their journey influence the quality of their experience.

5.1.3.1 MADs' Development Stages

The MAD user journey lasts for a period of approximately 11 years and is managed by a group of human stakeholders from a variety of backgrounds including trainers, volunteers, boarders, and veterinarians that support them during their working lives. It is divided into six main stages (Figure 9), each concluding with the dogs having undergone what is considered either a significant life event (e.g. weaning) or a developmental milestone (e.g. assessment of their skills and performance). The following sections describe these stages in detail.

Stage 1 - Breeding and Whelping

This stage includes all activities related to the breeding and acquisition of puppies who will be enrolled in the MAD training process, including the care and oversight of the brooding bitches during their pregnancy, birth, and first eight weeks of their puppies' lives. Most of these activities are carried out in the homes of Puppy Volunteers and are managed by the Puppy Supply team. During this time, nearly all the artefacts the puppies interact with (e.g. blankets, soft toys, and cardboard mats) are intended to provide them with a safe environment in which to spend their first weeks of life and are similar to those used by companion dogs; with one difference being that potential MAD puppies are purposely exposed to a large range of toys in a variety of shapes, colours, materials, and sizes to get them used to interacting with novel objects. When the puppies are 6 to 7 weeks old, they undergo a character assessment developed by the DFG puppy supply team that is intended to test their general reactivity to novel objects.
and new situations. It is usually carried out by a member of the Puppy Supply team, who described it as follows: “When I do their character assessment, I let them roam a bit around the house, either in the hallway, or the kitchen. Now I am using a new toy, a duck that quacks that they have never heard before, it’s the novelty … I want to see how they react. It’s a soft toy which is fun to play with as well. We spend 10-15 minutes with them and see what they do, if they run off with the toys or bring them back. If they want a cuddle … You’d think litters are even and, no, they are so different among themselves”. Once the puppies reach eight weeks of age, they are separated from their mothers and brought into DFG headquarters, where they undergo a health assessment. If the assessment goes well, they are taken to the homes of Puppy Raiser volunteers who will be their main caretakers during the next stage of their journey. If the assessment reveals a health concern, the puppies are given treatment while in the care of DFG staff; or if the health issue is of mayor concern, for example a birth defect which would prevent them from carrying out assistance work, they are then released from the program and rehomed as companion animals.

Stage 2 – Socialisation
This stage begins when the puppies arrive at their new homes and ends approximately 16-18 months later when the dogs are returned to the charity. During this time, Puppy Raisers are expected to care for the dogs and guide their development. To help them with this endeavor, they are provided with a DFG manual which outlines their main responsibilities, contains information on the dogs’ growth and development and provides general guidance on how to help raise a future MAD. Among the responsibilities given to Puppy Raisers are the completion of all veterinary (e.g. vaccinations) and wellness (e.g. weigh-in) check-ups. Additionally, DFG staff support Puppy Raisers in teaching the dogs basic obedience skills such as sitting, staying, and laying down; and in introducing them to new environments and situations which will be part of their working lives, including train stations, indoor and outdoor markets, and town centers. During this stage, the artefacts the dogs interact with are, mostly, regular products commonly used by companion dogs such as leads, food bowls, beds, blankets,
and toys; however, some products are particular to assistance dogs such as vests,\textsuperscript{21} and some basic training tools including wooden dumbbells, plastic spoons and metallic keys. When the dogs are approximately 18 months old or have reached a level of maturity good enough to begin training, they are returned to the care of DFG where upon passing a health and wellness check they are rehomed with Training Volunteers who will be their main caretakers for the next 4 to 6 months.

**Stage 3 - Advanced Training Stage (ATS)**

During the ATS, Training Volunteers are responsible for bringing the dogs to and from DFG headquarters, so that they can take part in advanced training activities. The stage begins once the dogs have been assigned to a primary trainer who will be responsible for all activities concerning the dogs’ training, including skills development and performance assessments. Skills development is carried out following a structured protocol developed by DFG, which involves incremental and positive reinforcement-based training (§4.3.2.2). During the ATS, the dogs are taught to exhibit specific MAD-related behaviours (e.g. remaining calm and being able to execute commands in various environments), while controlling other behaviours that might impact their performance (e.g. chasing after other dogs or squirrels). As one trainer commented “…we train the dogs to adapt to how we do things and our needs. Assistance doggies, sniffing, running, that is dog behaviour we are asking them not to do on the lead, but that is through training”. Additionally, the dogs are introduced to and taught how to interact with the majority of artefacts and devices that will be part of their working lives in a variety of contexts, including objects such as personal items (e.g. clothing and keys), technological devices (e.g. buttons and light switches) and mobility aids (e.g. wheelchairs and walkers).

Performance assessments, aimed at monitoring the dogs’ development and wellbeing during the 16-week training program, are carried out during weeks 6, 12, and 16. The ATS culminates with a 16-week assessment in which the entirety of skills and abilities required for the dogs to work as MADs are evaluated. If a dog fails to pass the evaluation for a reason that has been identified as easily solved through extra training they are allowed to re-take the assessment once the issue has been addressed; however, if they

\textsuperscript{21} Vests used by assistance dogs are commonly made of breathable and comfortable materials that are intended to be worn by the dogs at all times while working. Their aim is to help humans identify the dog as being ‘at work’ to prevent them engaging and distracting the dog.
fail due to a behaviour or issue which cannot be solved through extra training (e.g. uncontrollable prey drive), they are removed from the program and rehomed as companion dogs.

**Stage 4 – Matching**

In order to match the dogs with their human partners, the *Matching* stage, which begins during week 7 or 8 of the ATS, involves the ongoing evaluation of the dogs’ development. Although the *Matching* stage mostly comprises activities which do not require direct interaction with the dogs (except a possible meet and greet with a potential human partner), this stage is included in the MAD user journey due to the impact it has on their future, and to the fact that the decisions made during this stage are a direct result of the dog’s performance and behaviour. The *Matching* stage includes the evaluation of the dogs’ performance by all DFG staff who are directly involved with the dogs during the ATS, and includes results from the dogs’ 6 and 12-week assessments, the *Training* team’s review of the dogs’ behaviour and development, the *Health & Wellness* team’s report on the dogs’ health, and observations about the dog’s behaviours while in the care of the *Training Volunteers*. This collection of data is discussed by members of the *Training, Health & Wellness, and Client Services* team during monthly meetings called *Case Studies*. Here, potential clients awaiting MADs are considered and based on the assumed compatibility with the dogs’ profiles and their specific needs, are matched. Once a partnership has been identified, the dogs’ training protocols are adapted to respond to any unaddressed needs their future human partners might have; for example, frequenting a specific place the dogs have not yet been introduced to, or needing specific tasks to be taught. The aim of the stage is best described by one of the instructors who commented, “The whole point of the matching process is to reduce the dogs that come back from clients and for us to get it right the first time, so we sit down with the trainers at case conferences and we discuss the clients’ needs and the dogs that would match. We always have a plan B, meaning we have two dogs per client which could work”.


Stage 5 – Placement

The fifth stage of the MAD user journey begins once the dogs are certified as MADs and a match has been made. During this time, and for the next 4 to 8 weeks, the dogs transition from the homes of their Training Volunteers into those of their human partners. As a means to ensure that the match is successful for the dogs, their partners, and any other human or animal members of their partners’ households, the newly formed partnerships are closely monitored by DFG’s Aftercare team, who carry out first daily, and then weekly home visits. As the MADs adapt to their new environments, Aftercare staff might provide additional training needed to address any specific issues that appear during the transition, including for example the introductions to novel artefacts their human partner might need to make use of. This is done, because, as one member of the Aftercare team described, “some clients’ information might be outdated … their health might have declined or a change in their personal circumstances”. If a match is deemed unsuccessful, the MAD will be returned to DFG’s care until a new match is found, and the client will be placed back onto the waiting list.

Stage 6 – Aftercare

The final stage of the MAD user journey is the Aftercare stage and consists of two distinct phases: the first year after placement and the rest of the dog’s working life. The first year after placement is a highly critical time, as it is during these first 12 months that the partnerships establish their foundational bonds, learn to cohabitate with each other, discover each other’s preferences and personalities, and ultimately become a successful MAD partnership. In order to adequately support this first phase, monitor the progression of the partnership, and be able to quickly address and solve any issues that might arise; the Aftercare team provides a heightened level of assistance by continuing to carry out initially weekly and then monthly visits to the partnerships. The second phase, spans the rest of MADs working life and lasts for a period of approximately six to eight years, ending when the dogs are retired due to age, illness, or diminished ability to assist. During this time the Aftercare team continues to support the MAD partnerships through yearly visits and by providing remote emergency assistance. Yearly visits consist of an evaluation by an Aftercare team member of the dogs’ health and wellbeing, including their exercise routines, weight and any health problems that might occur, and
of the partnerships’ home environment; the evaluation also includes having conversations with other members of the household about the partnerships’ dynamic and accompanying the partnerships on an outing to observe them in action.

5.1.3.2 MADs’ Supporting UX Ecosystem

The analysis of data revealed that throughout MADs’ journey, their development, performance, and wellness was continuously monitored by DFG staff and volunteers; resulting in a system of continuous checks and balances which seemed to ensure that neither the dogs’ nor the clients’ welfare or wellbeing was ever compromised. In addition, in plotting and clustering the themed content, an inventory of the main elements including the stakeholders, environments, and artefacts MADs’ interact with during their lifecycle (Figure 10) was defined. The following sections consider the influence of each of these elements on the MAD UX providing a robust understanding of the richness and complexity of the ecosystem.

Figure 10: MADs’ supporting UX ecosystem
5.1.3.3 The Influence of Human Stakeholders on the MAD UX

For dogs to become successful MADs, the support of human stakeholders is essential, with a significant amount of human resources allocated towards providing the dogs with all the care, training, and support needed to become MADs. The types and number of human stakeholders who are both directly and indirectly involved with the dogs is significant, and includes trainers, health and wellness staff, training volunteers, and client services staff, all working together in support of the dog’s success. However, this labored and continuous support does not come without its challenges some of which are discussed below.

The Charitable Nature of the Assistance Dog Industry

As mentioned in §2.1.3.1, the assistance dog training industry is composed of charities such as DFG which, mostly, are dependent on volunteer-based resources. Although comprised of individuals who are very generous, well-meaning and have the dogs’ best interest at heart, the voluntary nature of their roles makes quality control standards hard to enforce; potentially resulting in negative consequences for MADs’ development. For example, during an interview with a member of the Aftercare team, they commented “It is sometimes hard to monitor the dogs because behaviours they do with their Training Volunteers that to them seem harmless, like chewing on an old shoe or sitting on the couch, can sometimes become an issue for the dog and cause other behaviours that might affect their training; and in the worst cases cause them to be taken out of the program”. Another example came from a member of the training team who, when discussing the seemingly simple task of introducing a dog to a new environment, commented how, if not done correctly, this “could potentially cause the dogs to develop an aversion to the environment, the things in it, or the environment itself, and affect their training”.

Varying Levels of Trainer Experience

During observations of training sessions, varying levels of trainer experience were witnessed, a circumstance which although not particular to DFG, is particular to the industry. This is due to canine training being a pedagogic discipline that, like other teaching, requires time and experience for expertise to be developed. Hence, it is only
through time spent training that a dog trainer develops the experience and knowhow required to train dogs in a way that positively influences their UX. For example, during a training session attended by a male Golden Retriever in this 14th week of training, his assigned trainer (T), the training team manager (TM) and me, the following critical incident was witnessed:

The session began on the pavement of a quiet residential street close to the dog’s home. While sitting in a wheelchair, T ‘inadvertently’ dropped her purse and issued the “get it” command to prompt the dog to retrieve it. The dog repeatedly failed at completing the task, even after T had offered an increased amount of verbal encouragement (“come on” and “you can do it”) and gestural prompts (pointing and leaning towards the dropped purse). T then commented: “He seems to be quite clever, I never taught him to pull or retrieve he just did it. Out and about I don’t know if he has an understanding of what he has to do, eventually he will do it, but maybe because I have not trained him to do certain behaviours he doesn’t generalize well and doesn’t realise that he has to do it in a new context? Could that be the issue?”. This revealed that the MAD seemed to have been successful at executing the command in previous sessions, thus leaving T, in this particular instance puzzled regarding his behaviour. T then gave the dog a short break from the session, and after a quick walk in the nearby area returned to the wheelchair and again dropped the purse and issued the “get it” command. This time, in addition to not responding to the command, the dog looked away from T and seemed to disengage from the training activity. Upon perceiving these behaviours, T stood up from the wheelchair, picked up the purse and then took a kneeling position close to the dog, from which she again dropped it and reissued the command. The dog remained unresponsive. T then exchanged the purse for a simpler object (a wooden dumbbell) and reissued the command. Again, the dog remained unresponsive. As a last attempt T adjusted the food reward, offering the dog a high value reward in the form of liver paste. Despite the many adjustments to the training protocol made by T the dog remained unsuccessful in carrying out the command. T and TM remained puzzled and unable to identify the cause of the dogs’ behaviour and had the following exchange:

TM: “It’s like a different dog isn’t he?”

T: “He makes you work for it, the retrieve. It’s not the vest and it’s not the harness.”
TM: “If this is him, he probably needs to go to someone who won’t go out as much … does he have any issues from before? I think I read that he might have had an incident?”
T: “This is the only area I can’t get him to do it … I do not recall if that could be the issue.”
TM: “It’s really strange, I have never seen it in a dog …”

For T to investigate TM’s claim, it would have required a review of the dog’s files, which at the time were inaccessible to T. However, the effect of changing training environments could easily be tested. Therefore, the training session was paused and continued inside at a nearby market. There, after wheeling around the market’s isles a few times, T once again dropped the purse and issued the “get it” command. This time the dog was quick to respond, picking up the purse and returning it to T.

The incident illustrated above clearly describes how T’s level of experience influenced the dog’s UX with the dog being arguably fortunate to be training with this particular trainer: who thanks to her experience, did not stop the session after the dog’s repeated lack of success, but instead ran through a comprehensive series of adjustments to the training protocol in the hopes of helping the dog succeed. However, not all trainers might have done the same, with some, for example, possibly terminating the session or negatively assessing the dog’s behaviour; in a sense making the MADs UX dependent on their level of experience and ability and/or willingness to modify the training protocols in a way that better met the dogs’ individual needs. Furthermore, although unable to explain what specific aspects might be affecting the dog’s ability to carry out the command, T and TM both recognized the possible influence of the dog’s handler on his behaviour. Finally, the influence of the environment on the MAD’s UX is self-evident, with the MAD performing better in an indoor versus an outdoor context. Yet despite being able to identify the aspects that influenced this MAD’s UX, and the fact that DFG staff had continually monitored his behaviour and interactions with other stakeholders, artefacts, and work environments throughout his training; the exact causes underlying the dog’s behaviour remained unexplained. This revealed that in addition to maintaining a system of checks and balances for MADs, in order for MADs to have their best chance at having the causes for their behaviour adequately and accurately considered; gathering data from various sources and analysing it in a systemic manner is needed; an ability which arguably comes with trainer experience.
Identifying Non-verbal User Needs

Another instance in which MADs’ UX was influenced by human stakeholders is associated with the difficulty of interpreting and identifying MAD user needs in an accurate, clear, and explicit manner, which is mostly due to the non-verbal nature of dogs’ communication. Although previously identified, a critical instance which clearly exemplified this challenge was observed during the study and consisted in the following: While seated in the trainer’s office, in which MADs in training are sometimes kept throughout the day, I observed one of the MADs present pacing and whining. Upon hearing the whining, one of the trainers offered the dog a few calming words and tossed him a toy to play with. However, the dog whined again shortly afterwards. Even though, to my knowledge, this behaviour had just begun, another staff member expressed concern and phoned the dog’s trainer to alert her of his behaviour. Later on, while interviewing the MAD’s trainer she made the following comment: “This afternoon the fact that someone called me and told me my dog was quite stressed in the office, I don’t know what it was that particularly caused that. I took him out this morning, I did not take him out at lunch but it’s not like I usually do. It’s not like there is much change. I did pop into the office but then I have done that many times before. I don’t know. Was there lots going on or very little going on? Did he need to toilet? Because there are so many things we don’t see. Had he been on a walk or not? Is he anticipating other things? But the fact that we came in here and within a few minutes he fell asleep, you know it could have been very isolated to that situation. If he was still pacing here, I would be like, oh maybe he has an upset tummy or what has happened today, then send an email, has anything been different? Have there been any changes? Who knows?"

In considering the events described above, although the trainer knew to contemplate the dog’s usual temperament and the context in which the reported behaviour had occurred in their assessment of its cause, they could have been mistaken in their interpretation causing the dog’s needs to remain unmet. Furthermore, when the trainer in the training room described the dog’s behaviour to the dog’s main trainer over the phone, their use of vocabulary might not have been clear or consistent, with one trainer reporting the dog’s behaviour as anxious while the other, if present in the room, could have interpreted it as excited. Moreover, when reporting the dog’s behaviour to their
main trainer, there was no mention of the duration of the behaviour, only its frequency. While this information might appear to be of minor importance, its inclusion or omission implies important assumptions on the part of all human stakeholders involved. For example, I interpreted the behaviour as a non-issue due to it having just begun, even though it might have been ongoing throughout the day without me being aware of it. On the other hand, the trainer reporting the behaviour assumed the frequency of the whining to be enough to warrant calling the dog’s trainer, even though the whining might be a behaviour that dogs exhibit sporadically. As a result, the dog’s trainer might have assumed that the behaviour had possibly increased in frequency or duration, a conclusion which might contradict their prior assessment of the dog’s habitual behaviour. Any of the interpretations of the dog’s behaviour described above could be accurate; however, without knowing the nuances of the dog’s behaviour in an explicit manner, any of the above interpretations, could also be wrong. This highlights the ways in which human stakeholders can impact the evaluation of a dog’s behaviour and cause their performance to be assessed incorrectly, resulting in potentially unnecessary interventions, and ultimately impacting their ability to become MADs. To mitigate this challenge, DFG staff are constantly assessing the dogs’ development, welfare and wellbeing through the collection, recording, exchange, and analysis of data related to the dogs’ progress. However, in order to prevent human stakeholders’ diverse backgrounds, related biases, and varying levels of expertise from influencing the MAD UX while trying to overcome the non-verbal nature of dogs’ communication, their behaviours need to be described in an accurate, clear, and explicit manner.  

From One Home to Another
During the course of their journey, MADs experience a minimum of four re-homings, each producing a significant amount of change in their lives, including a change in handlers, the humans they interact with, their geographical location, their home environment, their canine friends, and their overall activities and routines. Although all

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of these factors are influential, due to the importance of the relationship between dogs and humans, the change in handlers might be a factor which affects them the most, followed by the change to their routines during the ATS, in which they transition from a lifestyle similar to that of a companion animal, to a Monday-to-Friday 8-hour intensive training schedule. The sum of all of these changes can take a toll on the dogs’ emotional state, with some dogs at times exhibiting behaviours such as increased barking, attributed in this case to the dogs’ difficulty in adapting to the changes. As one trainer commented “when the dogs arrive for training, we usually hold back on any judgment as they are still getting used to the way things are, for example you might get a dog that the first few weeks seems anxious or seems to bark a lot but then they calm down.” Even though all human stakeholders involved in MADs’ training process share the common goal of minimizing any negative influences on the quality of their UX, their current journey and the challenges in it can ultimately affect their ability to become a MAD.

5.1.3.4 The Influence of the Environments

During the course of their lifecycle, the dogs are exposed to a variety of environments, ranging from homes, offices and shopping malls, to parks, and train stations. Each environment presents a unique set of artefacts and devices; sounds, smells, and textures; population densities and overall size. Arguably, the gap between the dogs’ experience and our own makes it impossible for us to fully understand the impact of each environment and the influence it has on them; however, by observing their behaviours within some of the environments they are commonly expected to work in, we can begin to understand the level of influence on their UX. For example, in the training session described in §5.1.3.3, the trainer took into consideration the change in environment as a possible cause for the behaviour, comparing the environment in which the dog had previously succeeded in executing the command -the DFG training room-to the current environment where the dog was struggling to do so. Thus, she was able to identify a mayor difference between the training environments -the training room being indoors and the pavement being outdoors- and further investigate if this change was the cause for the dogs’ behaviour by moving the session into a nearby store, where the issue was resolved and the dog was able to complete the command successfully.
5.1.3.5 The Influence of the Artefacts and Devices

During their journey, MADs are exposed to a large array of artefacts and devices they are expected to be familiar and, in certain instances, interact with. Some of the interactions involve, for example, them retrieving an object on behalf of their human partner, while others require the dogs to directly come into contact with and activate a device. Based on the observations of MADs during their interactions with such artefacts, the amount of influence said artefact had on the quality of their UX was evidenced to relate to the type of interaction; allowing these to be classified into three main types: indirect, direct and active.

Indirect interactions are those in which the dogs interact with an object only indirectly, for example when walking alongside a wheelchair. Here, although the wheelchair remains independent of the dog, they must be familiar with it and be aware of its position and movement in order not to collide with or be harmed by it. Direct interactions are those in which the dogs interact with an object or artefact directly, for example, when retrieving fallen objects such as phones, purses, or keys, or when pulling on sleeves in order to help their human partner undress. In these instances, the artefacts are manipulated by the dogs, but the interaction does not require them to activate or change the artefact in any way. Active interactions are those in which the dog interacts with an artefact or device directly thus changing its status, for example when pushing an access control and changing its state from not activated to activated.

The artefacts, products, and devices that MADs have an active interaction with on behalf of their human partners, are mostly intended for human use. However, it could be argued that, although they may not be the primary users of the artefacts, as a part of the assistance work they are trained to carry out, the dogs’ interaction with the product is highly dependent on the artefacts’ design. For example, a dog being trained to use a wall mounted light switch in order to be able to turn lights on and off on behalf of their partners was observed during the study. This particular dog was on the shorter side, which caused her to have to jump up to even be able to reach the switch, and then use her paw to try to hit it with enough force to cause it to switch down and turn the light on. This was repeated for turning the light off, an action which seemed to require even more effort for the MAD who now had to target an even smaller area of the switch.
to make it work. Here the artefact itself is clearly designed for human use, being installed at a height accessible to a human, requiring somewhat fine motricity and motor skills to accurately target the switch, and enough force to switch its position. That the dogs can be trained to work these switches is not what is important, instead it is the fact that to do so they must engage in behaviours that can be detrimental to their health (e.g., constant jumping); hard for them to use (e.g. paws have less motricity than fingers), and result in an overall unpleasant experience. Thus, evidencing the fundamental influence of the design of the artefacts, products and devices MADs interact with have on their performance and the quality of their UX.

5.1.4 Discussion

The findings reported above evidence the influence of MADs supporting ecosystem on their UX, performance, and wellbeing. The following sections discuss these findings in relation to a UCD approach to understanding MADs’ contexts of use.

5.1.4.1 UCD Approach to Understanding MADs’ Working Environments

In order to contextualize the UX, researchers rely on their ability to correctly understand and interpret the user’s individual point of view. However, due to a users’ experience being a dynamic and highly individual process (§2.2.3), it could be argued that it cannot be understood by any person other than the entity going through the experience. Yet there are various ID methods which have proven to allow designers to at least investigate the UX to a degree which enables them to design for it. However, when it comes to investigating the animal UX, our human-ness significantly influences and at times impedes our understanding of what exactly the animals’ experience, or what that experience means to them might be. Hence, designing for animals presents an added level of complexity for the designer, who cannot embody the intended user, but rather assumes the responsibility of acting as the interpreter of the animal’s behaviour throughout the entire design process. To this end, we can apply our powers of observation, empathy and critical thinking to gain some understanding, if not of the exact experience itself, at least of the animal user and the elements that comprise and influence their experience. As evidenced in the findings, this is by no means an easy process; however, the empiric investigation of MADs’ contexts of use from a UCD
perspective enabled me to gain a robust understanding of the conditions and elements which compose their UX ecosystem, how they relate and interact with each other, and be able to define and acknowledge the many challenges ahead. For example, by increasing the awareness on the need for the correct application of methods that support the accurate, systematic, and clear interpretation of MAD behaviour.

5.1.4.2 The Influence of MADs’ Supporting Ecosystem on their UX

As evidenced in the findings, MADs user journey is supported by an ecosystem comprised of a variety of stakeholders, artefacts and environments that are in constant interaction with the dogs and with each other. This results in an abundance of opportunities throughout MADs journey to improve their UX; for example, by designing a set of toys made with the purpose of helping assistance dog charity staff to better gauge the puppies’ propensity towards assistance work. However, the focus of this research is on investigating MADs active interactions with the artefacts in their environment; hence, here we focus our attention on the stages during which these types of interactions commonly occur, specifically the Advanced Training and Aftercare stages. Additionally, our findings revealed the focus on the ATS to be fundamental to the research, because it is particularly during this time when the dogs are taught the specialised skills that will allow them to become MADs.
5.2 Formative Study 2: The Advanced Training Stage (ATS)

Informed by the findings of the previous study and in an effort to deepen our understanding of MADs’ context of use during the ATS, this study consisted in another visit to DFG’s facilities during which observations and interviews specific to the ATS were carried out. Findings included a more detailed version of the MADs user journey, specifically focused on the ATS which in turn led to an emergent set of MAD user requirements.

5.2.1 Participants

Participants in the study included 5 DFG training staff and 8 dogs in training. DFG training staff included 1 training manager, 1 full time trainer, and 3 part time trainers. The dogs in training included 4 males and 4 females aged between 18 and 24 months, all Golden Retrievers, Labrador Retrievers or Labrador/Golden Retriever crosses. All MADs were currently in the ATS, ranging from week 5 to week 8 of training, and were fully proficient in some of the skills required as MADs.

5.2.2 Methodology

The study took place at DFG’s headquarters over the course of five-days (Monday March 19th to Friday March 23rd, 2018). The research plan and the study materials, including interview protocols and data collection methods were developed by me; however, due to a 2-month suspension from the research to address personal health concerns, the data collection was carried out by Elizabeth Cox (the Open University’s ACI Lab’s visiting research fellow). Upon my return, Elizabeth and I collaborated during data analysis where her expertise in canine behavioural studies and canine veterinary care provided a valuable contribution to the research.

Data collection methods included four semi-structured and one contextual interview with DFG training staff. The interview protocol contained questions regarding the trainer’s past work experience, their experience of monitoring and evaluating the dogs’ development during training, how they established and developed bonds with the dogs and information about the training exercises, and tools used during the ATS (Appendix 6). Additional data was collected during the recording and observation of ATS training
sessions which focused on the training of operational commands such as “push” and “nudge”, and which are intended to teach the dogs to engage in active interactions with tangible technological interfaces. During the sessions, the dogs were mostly rewarded with food (bits of kibble or liver paste) although verbal (e.g. “good lad”) and/or physical (e.g. petting) rewards were also given. The frequency, value, amount and type of these rewards was determined by the trainers and was based on the level of difficulty the task being trained presented for the dogs.

5.2.2.1 Content Analysis

Using a process similar to that of the previous study, interview data was coded using a predetermined code list which had been defined based on the areas of inquiry addressed during the interviews. Participant responses that did not belong to any of the predetermined codes were coded using a set of emergent codes (Appendix 7). The dataset was coded a third time using a base order coding approach. Base order coding consists of coding the content using as many codes as deemed necessary, with the first code applied being the most reflective of the content and the second code applied being the second most reflective, and so on (Neuendorf, 2016). To ensure coding inter-reliability, base order coding was carried out individually by Elizabeth and me, and then compared. Any inconsistencies were addressed through discussion. The result revealed three distinct content themes based on which particular stakeholder had been directly or indirectly interacting with the dogs, including DFG staff, their assigned trainers, and their human partners.

5.2.2.2 Understanding the Human Impact on the MADs’ UX

Similar to the dynamic clustering approach of the previous study, the content assigned to each theme was analysed using a subset of categories related to the dog’s cognitive, physical, and sensory characteristics, their performance and wellbeing. This was done with the aim to investigate to a higher degree of detail the type of the influence the different stakeholders had on MADs during the ATS. For example, a data point belonging to Theme 2: MADs and Trainers consisted in: “Changes in material are taught incrementally because some dogs really struggle with “cold” materials like metal”. In order to help categorize the data correctly the following questions was asked;
“Considering the data, which of the categories best describes the way in which the MAD's UX would be impacted?” In this case, the highest level of impact would probably be on the MAD’s sensory characteristics as the content is describing something to do with touch and feel. However, although this approach allowed us to cluster the data based on the category which seemed to have the most impact on the MADs’ UX, unless several copies of the individual Post It® notes were made, other categories which might also be pertinent could not be identified. Hence, a matrix was created in Microsoft Excel which contained the themed data points on its vertical axis and the categories associated to MADs cognitive, physical, and sensory characteristics, and their performance and wellbeing on the horizontal axis. Then in order to be able to assign a degree of influence, a simple rating scale of 1 to 3 was defined, where 1 indicated low impact and was labeled in blue, 2 indicated some impact and was labeled in green and three indicated high impact and was labeled in red (Figure 11 shows a snapshot of the matrix).

<table>
<thead>
<tr>
<th>Trainer Data</th>
<th>Code</th>
<th>MC</th>
<th>MS</th>
<th>MP</th>
<th>MR</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>The dog’s range of movement impacts how easy or hard it is to train certain commands and use of objects</td>
<td>(T) Training process</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trainers adapt their methods to set the dogs up for success, so they can cope and maintain their happiness or welfare</td>
<td>(OC) Operational Commands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dogs open wheelchair footplates using their paws because some require a significant amount of force to be applied</td>
<td>(TA) Tools used during training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requires high confidence because it demands different physical outputs depending on what they are pulling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changes in material are taught incrementally because some dogs really struggle with “cold” materials like metal</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Our storage room makes you realise the number of different things dogs come into contact with during training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 11: Data analysis matrix

5.2.2.3 Defining MADs’ Active Interactions

In order to further investigate the types of artefacts MADs interact with during the ATS, the themed content was again clustered into the different types of interactions identified in §5.1.3.5, including indirect, direct and active interactions. This allowed us to empirically confirm the types of artefacts MADs have active interactions with and use these as a way to narrow the scope of the research (Figure 12).
5.2.2.4 Insights, Problem Statements and “How Might We” Questions.

The data analysis described above provided a more detailed understanding of MADs’ experience during the ATS, specifically related to their active interactions during the execution of operational commands. However, because the aim of the research is to design a canine-centric interface, the dataset was reviewed a final time in an effort to reformulate the content into more actionable statements with which to inform the interface’s design.

First, a set of insights pertaining to MADs active interactions during the ATS were extracted. Insights are concise statements which contain data previously unknown to the research team and which relate to users’ unmet needs (Kumar, 2012). Although insights serve to state a user’s current situation, they do not articulate the problem to address. To do so, the insights were reformulated into problem statements. For example, an insight, such as “A dog’s interactions with tangible interfaces are influenced by the dog’s degree of mobility; making the form factor of the artefacts, the way they are placed, or their location important factors to consider”, is reformulated as a problem statement as “Depending on a dog’s individual physical characteristics and capabilities, some of the artefacts they use are difficult for them to access and interact with.” This change in wording clearly expresses the problem to be solved. Then, in order to help address the problems stated from a broad perspective and spark ideation, How Might We (HMW) questions (IDEO.org, 2015) were generated. I considered this to be an important step at this point in the research due to the studies having produced a series
of design constraints which would be easier to address by, for the purposes of ideation, taking a purely creative and constraint free perspective (Table 2).

5.2.3 Findings

Findings included a more focused and detailed MAD user journey for the ATS, a deeper understanding of the artefacts MADs actively interact with and their impact on their cognitive, sensory, physical, emotional, cultural, and social characteristics. Additionally, a set of insights, problem statements, and HMW questions were used to clearly articulate the problems to be solved, promote ideation and further refine the set of MADs’ user requirements.

5.2.3.1 The ATS MAD User Journey

The ATS is the stage during MADs’ user journey in which the dogs learn the skills needed to become MADs including learning operational commands such as “pull”, “give”, “push” and “nudge”. For this reason, the ATS emerged as the stage with the highest influence on their performance and wellbeing, as it is here when their ability to become MADs is determined. The ATS lasts for a period of approximately 16 weeks divided into three main phases (Figure 13), during which the dogs mainly interact with their Training Volunteers who are responsible for their care and boarding, and their trainers who are responsible for teaching the dogs the complete set of skills they will need to learn in order to become MADs. Each phase of the ATS concludes with an assessment of the dogs’ performance used to measure their skill level and determine if they can continue to the next level of training, if more training will help them pass the assessment, or if they need to be withdrawn from the program and rehomed as companion dogs. The following sections provide a detailed description of each phase.
Phase 1 - Bonding (Weeks 1-6)

The first six weeks of the ATS are focused on activities in support of the establishment of a bond between the dog and their trainer. This is a critical step, as developing a strong bond has shown to increase the dogs’ chance of successfully completing the training. This is partly due to it allowing the trainer to get to know the dog’s preferences and provide them with individualized support and be able to quickly identify and address any behaviours which might be considered undesirable or problematic such as distraction, anxiety, high prey drive, or separation issues. Doing so requires the trainer to be continually observing the dog with the aim of assessing their temperament, learning style, and level of sensitivity to different environments and stimuli. As FT1 commented “By knowing the dogs we know when to call it quits or when to push a bit and say - we can work through this in order to get you through a rough patch and get them to the other side.” This phase also includes other activities such as the monitoring of the dog’s successful transition from the home of their Puppy Raiser to that of their Training Volunteers, and from their previous “pet dog” schedule to their new, more intense MAD-in-training schedule. As PT2 commented “Separation issues matter, it does crop up problems, you know, they have just changed homes and now you are their world, their source of treats and fun and at the end they will have to transition again, so making sure the dogs cope is important”. 
Furthermore, these first six weeks incorporate basic training sessions, during which skills such as walking on a lead without pulling, exhibiting a strong recall\(^{23}\), sitting and staying are reinforced. In addition, basic training sessions are also used to introduce the dog to the many objects they will be expected to interact with as part of their assistance work such as personal objects, mobility aids, and devices. In order to reduce the amount of potential distractions for the dog, cement the bond with the trainer, and help build their confidence in carrying out basic commands, most sessions during this phase are carried out at DFG headquarters. However, if the trainer perceives the dog to be relatively strong in their performance of basic skills, they might conduct some of the training sessions outside DFG headquarters in environments with reduced distractions such as residential areas and parks. Here, the dog can begin to adapt to the various elements within these environments while learning to remain focused on their trainer. This phase ends with an assessment carried out by the dog’s trainer and a member of the training team during which their ability to proficiently execute the basic training skills described above is evaluated. The assessment usually consists of the trainer taking the dog out for a walk either at DFG headquarters or in an off-site environment, during which a range of commands are executed while a member of the training team observes and evaluates the dog’s performance. As FT1 commented “The 6-week assessment is about understanding what areas need to be worked on more in the different environments, and what the next 12 weeks will need to be like for the dog”.

**Phase 2 - Advanced Training (Weeks 7-12)**

During the following six weeks the dog solidifies their basic training skills and is introduced to more complex operational commands such as: a) “push” - using their paws to push objects; b) “nudge” - using their snout to push objects; c) “pull” - using their mouth to pull objects; and d) “give” - picking up and returning objects. To illustrate the incremental nature of the training protocols used to train such commands, Figure 13 describes the training protocol used to train the operational command of “nudge”.

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\(^{23}\) Recall is when a dog is taught to immediately return to the handler after the recall command has been issued.
Figure 14: Graphic depiction of the steps for training the “nudge” command

The sequence illustrated above describes the level of attention to detail the training of operational commands requires. This is mostly due to the need for dogs to be fluent in every step of execution of an operational command since the same command might require them to interact with a range of different objects. For example, the “give” command might require the dog to interact with: training tools (e.g. wooden dumbbells, ropes, and paper), clothing (e.g. socks, jackets and jumpers), personal objects (e.g. keys, wallets, and cellphones), and household objects (e.g. food items, remote controls, and wardrobes). As FT1 commented, operational commands “make you look at all the different objects and devices they have to use and appreciate how many different types there are and how good some dogs have to be to generalize and use all of them”.

In order to prepare the dog to reach fluency in executing assistance work wherever their human partner might take them, this phase also involves conducting a significant number of training sessions outside DFG headquarters. As per DFG training standards, MADs are expected to carry out assistance work while in the following 17 environments: busy town high street, quiet residential area, busy residential area, retail park, market, supermarket, indoor precinct, bus and train station, cafe, pet shop, outdoor school, park, lifts and escalators, stairs and steps, rural setting, veterinary surgery, and home.

This second phase culminates with a 12-week assessment, which is based on the dog’s ability to carry out the complete set of skills taught to date and consists of four evaluations; one carried out at DFG headquarters, and the remaining three in...
environments which have shown to be a challenging for the dog. In order to evaluate
the dog’s comfort with mobility devices, the trainer uses a variety of mobility aids such
as walkers, wheelchairs, and/or crutches. Other skills are also assessed, including the
dog’s behaviour during car travel, their ability to remain calm in busy and noisy
environments (e.g. bus and train stations), and their level of comfort with being
groomed and touched in areas known to be sensitive (e.g. underside of paws).

Phase 3 - Finishing (Weeks 13-16)
The final phase of the ATS can, in some cases, be the most intense for the dog in terms
of training, due to new requirements that are added to their schedule as a result of any
specific needs their newly matched human partner might have. As PT3 commented “We
may go out and do a recall session with the client, so they know exactly how the dog
carries out recall and realise there might be some adjustments we need to make”.
Furthermore, these last four weeks of the ATS are the time when the dog is expected
to be fluent in the execution of all operational commands.
At the end of this phase the dog undergoes their final assessment during which their
performance of all commands (basic, obedience and operational), while in proximity of
a mobility aid (e.g. wheelchair) in any one of the 17 environments the dogs are trained
to work in are tested. Additionally, the dog is expected to exhibit a strong and
dependable recall even in the presence of other dogs, have a consistent and accident-
free toileting routine, demonstrate controlled behaviour during travel, and remain calm
during grooming and handling activities. Some of the behaviours related to the dog’s
general comportment are certified by an external evaluator from the United Kingdom
Kennel Club who assesses the dog’s performance. If successful, the dog is awarded a
Good Citizen Certification, which is recognized as the standard for MAD certification in
the UK. All other behaviours and skills are internally assessed by the DFG training team.

5.2.3.2 Insights, Problems and Ideation
Table 2 contains the most relevant insights, the resulting problem statements and
ensuing HMW questions regarding MADs’ unmet user needs, specifically related to their
active interactions. By formulating these insights, we were able to deepen our
understanding of the specific influence that the users, artefacts and environments have on MADs during the course of the ATS.

1. **Insight** – In order to ensure MADs are fairly assessed DFG staff and volunteers are continuously using a mix of digital and analogue formats to record their behaviour; however, this makes the data hard to analyse, potentially resulting in incomplete or inaccurate evaluations.

**Problem Statement** – In order for MADs to be fairly and accurately assessed during training, DFG staff and volunteers should be able to consistently record their behaviours.

**How might we …**

- Standardise the process of data collection?
- Automate the recording of MADs’ dog’s behaviours?
- Create interfaces that can capture and analyse MAD’s performance during training?

2. **Insight** - In order to address the needs and learning styles of individual MADs; trainers usually modify training protocols.

**Problem Statement** – A MAD’s training experience is highly dependent on their trainer’s ability to modify the training protocols.

**How might we …**

- Design interfaces that adapt to MADs’ individual training needs, while keeping training protocols consistent?
- Help trainers choose the best training modification for MADs?
- Design interfaces that allow the dog to influence how their training is adapted and taught?

3. **Insight** – Although commands express a specific action, the different interfaces MADs interact with to execute a command might result in them having to choose from a range of possible behaviours to perform.

**Problem Statement** – The interfaces MADs interact with during training do not provide them any guidance in choosing which behaviour to perform in order to execute the command (e.g. “pull with force”).

**How might we …**

- Adapt the interfaces that MADs use during training to help them know the specific behaviour that needs to be performed?
- Design interfaces that work with consistent modes of operation (e.g. same amount of applied force)?
- Design interfaces that provide MADs with feedback to choose the correct behaviour needed to interact with them (e.g. status bar to indicate more force is needed)?
4. **Insight** – MAD’s degree of comfort when interacting with interfaces that require them to use their paws, mouths and snouts is significantly influenced by their material.

**Problem Statement** – Some of the interfaces MADs interact with during training are made of materials that are uncomfortable for them to interact with.

**How might we ...**
- Design interfaces that are comfortable for MADs to use with their paws, snout, and mouth?
- Adapt current artefacts MADs interact with so that they are comfortable to use with their paws, snout, and mouth?
- Afford MADs a way of interacting with interfaces that do not require them to use their more sensitive mouth or snout?

5. **Insight** – When a command is issued, usually the only form of feedback provided to MADs is upon successful completion; however, this leaves them uncertain of when a command is near to completion (e.g. heavy door pull).

**Problem Statement** – MADs are not provided with status feedback during their execution of commands, leaving them blind to factors that ensure successful completion such as duration and force.

**How might we ...**
- Design interfaces that give MADs a status feedback as to the rate of command completion?
- Design interfaces that provide trainers with ways to know the duration the MADs’ behaviour needs to be sustained?
- Design status signals that can be added to current interfaces MADs interact with?

6. **Insight** – Training time is incredibly limited, so anything that helps speed up training without compromising learning and performance is of high value to the assistance dog training industry.

**Problem Statement** – A MAD’s training time is limited, however the current interfaces used for training are not designed to maximize training time.

**How might we ...**
- Design interfaces whose features help reduce a MAD’s training time?
- Design interfaces that track a MAD’s performance to make training time more efficient?
- Generate individualized training protocols that modify the interfaces used for training in order to respond to MAD’s individual training abilities?

| Table 2: Insights, POV problem statements and HMW questions of the ATS |

5.2.4 **Discussion**

The findings reported above have provided a comprehensive understanding of how humans, working environments, and the artefacts and devices MADs interact with
influence the quality of their experience during the ATS. The following sections discuss these findings as they help inform the definition of constraints and requirements related to the design of technological devices for MAD use.

5.2.4.1 Constraints

The Training Window

Training dogs into MADs is heavily constrained by time; influenced, partly, by: i. the level of maturity the dogs need to reach in order for them to be able to learn and become fluent at executing advanced skills; ii. the costs that can be afforded by the charity to support MADs’ training process; and iii. the rates of successful MAD placements and the lifespans of MADs’ working lives. The result of these constraints on time is a 6-month training window which opens at around the time the dogs are 18 months old and closes when they are around 2 years old. However, if the dogs fail to successfully complete their training during the training window, DFG’s costs will most likely exceed their available resources and potentially compromise their ability to provide the dogs with the needed skillsets, while still ensuring their welfare and performance. Thus, any time that can be saved or reallocated towards other activities during the ATS is significantly valuable to the dogs and the charity. In addition, from the perspective of the MAD partnership, any time saved during the ATS leaves time available for the dog to be taught additional skills based on their partner’s specific needs. Indeed, any action or resource allocated towards reducing the amount of friction between parties who are expected to form a deeply interdependent and bonded partnership is crucial. Thus, finding ways to maximize the training window is essential, whether it be through protocol development or the design of artefacts and devices that reduce training times.

Environmental Sensitivities

Dogs have been known to exhibit heightened levels of sensitivity to novel environments (§5.1.3.4), a condition which is worthy of consideration in the case of MADs due to them being expected to assist their human partner in a wide variety of contexts. In addition, it is due to environmental sensitivities that some dogs are removed from the training program or are matched with partners that can guarantee them fixed routines within certain environments (consider the example given in §5.1.3.3). Thus, working within the
constraint of dogs’ heightened sensitivity to novel environments becomes important. This might be achieved through the development of training protocols that somehow ensure the dogs’ exposure to any environment remains positive and does not have any negative or long-term effects on their ability to assist their humans; or it might be achieved through the design of tangible interfaces that, when placed within the dogs’ working environments, become signals of continuity and help the dogs habituate to the situation.

5.2.4.2 Requirements

Operational Commands
The findings from these two studies fully confirm the importance of operational commands as those which the MAD partnership relies on in order to be successful. However, the way in which the commands are currently trained requires the dogs to generalize their execution across a significant range of situations, environments, and devices while carrying out different behaviours.

Let us consider, for example, the command “pull”, which depending on where, when, and how it is issued requires the MAD to execute different behaviours (Figure 14). If issued while the MAD partnership is standing in front of a closed door that has been outfitted with a door pull (usually a piece of rope or fleece that has been hung from the handle), the dog is to bite the pull and begin to tug in the opposite direction with enough force to open the door completely, but not as forcefully as to swing it open potentially hitting themselves or their human partner. Alternatively, if issued when the human holds their arm out, the command means that the dog should bite the cuff of the humans’ top with enough strength to be able to pull on and remove the sleeve, but not as forcefully as to cause the human any unintended movement which might harm them. If it is issued to ask the dog to unzip a jacket, the command requires the dog to prop themselves onto a surface (e.g. wheelchair footplates, or the human’s lap) in order to reach the zipper pull, then bite this small metallic object, and pull away and down so as to open the zipper without pulling the human forward in a way that could cause them harm.
Based on our knowledge of canine cognition, generalizing the execution of operational commands is not an easy feat (Serpell and Barrett, 2017, Grandin and Johnson, 2009), in fact it is something that can be quite challenging for the dogs and can potentially lead to their release from the program. Thus, modifying the way operational commands are taught so that they provide the dog with more detail into how they should be executed would be important. However, doing so would require that the increase in the level of detail of each command does not produce a significant increase in the number or complexity of the commands, because doing so would potentially cause the dogs confusion or increase the amount of training time. A potential solution could be through the design of interfaces whose features could provide MADs' with clear instructions on the behaviours they need to perform in order to successfully interact with them or could afford them the ability to interact with them while performing the same behaviour and obtaining different outcomes. For example, in considering the use of a zipper as described above, having a smart zipper that provides the dog with some sort of feedback (e.g. vibration or sound) regarding the amount of force they are exerting.

Mitigating the Human Influence on the MAD UX
The human influence on the quality of MADs experience is clearly evident. In fact, due to humans being the ones who have created and afforded dogs this type of development and training, they exercise complete control over their user journey and thus the quality of their experience. The challenge then becomes guaranteeing that the impact of the human’s influence on this process results in positive outcomes for the
dogs and does not, for example, hinder their development due to procedural inconsistencies or lack of available tools. The design of devices for MAD’s could support the role humans have throughout the process, for example by designing features that provided feedback for the human regarding the dog’s success rate when interacting with it and help them answer questions such as: Did they push it hard enough, did they activate it? This would help to reduce the amount of guess work required of the trainers and potentially decrease the amount of procedural errors committed by humans.

**Designing for the MAD User**

In regard to the influence of the artefacts and devices MADs currently interact with, most of the impact stems from the fact that their design is informed by human user needs as opposed to those of the dogs. Currently these interfaces are not unusable by the dogs but, clearly pose usability challenges for MADs. Given our role as custodians and designers of the MAD experience it is our responsibility to provide interfaces which respond to MAD user characteristics and capabilities. In order to do so, we need to investigate how to define, test and evaluate the design features that would afford MADs’ improved usability and UX.

**5.2.4.2 Measuring the Animal (MAD) UX**

In the past two studies, although we have gained a robust understanding of how MADs’ supporting ecosystem influences their UX, we remain unsure of what their impact on their UX actually is. Thus, the approach moving forward must rely on methods which will provide additional more objective measures and which due to the focus of the research help measure MADS interactions with the artefacts and devices they currently interact with. Thus, my approach going forward is focused on investigating methods and tools which can help me more objectively understand the MAD experience through their use of tangible interfaces, specifically during the second and third phases of the ATS, and Aftercare stage.

**5.2.5 MAD User Requirements**

Based on the data presented in the two previous studies, a set of emergent MAD user needs are presented below.
• Due to the **influence of human stakeholders** on the MAD UX, MADs would benefit from devices whose design helps trainers capture certain aspects of MADs’ interactions (e.g. number of contacts).

• Due to the varying **levels of trainer experience** and their influence on the MAD UX, MADs would benefit from devices whose design supports the trainers’ actions while training (e.g. automatically delivery of rewards).

• Due to the **unspecific nature of commands** MADs are taught to carry out on behalf of their partners, MADs would benefit from devices whose design orient them in terms of the specific behaviour expected of them.

• Due to MADs exhibiting a **preference for different types of materials**, the devices’ features should be made of materials that, based on the intended mode of interaction, respond to their preference.

• Due to the **variety of artefacts and interactions** MADs are expected to execute on behalf of their human partners, the devices’ design should afford some type of feedback related to what a successful execution of the command entails.

• Due to MADs’ **training window**, the devices’ design should consider the inclusion of features which might help maximize MADs’ training time.

### 5.3 Chapter Summary

This chapter reported on two studies aimed at deepening our understanding of MADs’ contexts of use and working conditions throughout their user journey; specifically, during the ATS. They provided us with a robust understanding of how the users, environments and artefacts they interact with influence the quality of their experience and which remain to be investigated. The first study produced MAD and human stakeholder user journeys which made evident the complex ecosystems that support them and they degree of influence they have on their UX. Additionally, MADs’ interactions types were defined, enabling the focus of the research to be on the ATS the training of operational commands and MADs active interactions. The second study provided a detailed account of MADs’ active interactions, the training protocols used to train them, and the devices they commonly interact with to do so. Additionally, a set of emergent MAD user requirements were also presented. The studies demonstrated that when carrying out research within the discipline of ACI, a UCD approach allows for
a comprehensive evaluation of current MAD working conditions in order to understand their UX, while allowing and supporting the constant reflection on what designing for another species entails. Although the entirety of the study’s data was collected at DFG, and based on their internal practices and team roles, we are confident that the findings constitute an accurate representation of common assistance dog industry practices.
Phase 3: Investigating MADs’ Interactions with Technological Devices
6. Investigating MADs’ Affect and Usability-based Interactions

This chapter reports on two studies aimed at addressing the second supporting research question, (sQ2 “What methods might ACI practitioners use to inform the design and evaluation of canine-centric interfaces?”), by investigating MADs active interactions with tangible interfaces; specifically, on their use of access controls. The first study investigated MADs’ affect-based interactions while interacting with a standard issue access control (SIAC) and was focused on their tail wagging behaviour. The second study investigated the usability of two types of access controls, a SIAC and a set of early prototypes previously developed by Mancini et al. (2016). The studies defined a comprehensive, individually focused approach to evaluating MADs’ UX and the findings helped to further define the set of MAD user requirements to inform the design of canine-centric devices. The following sections report on the two studies in detail.

6.1 Investigating MADs’ Affect-Based Interactions

Data collection for this study included MADs behaviours while interacting with a SIAC and the assessment of their individual personality traits as scored by their trainers. Data analysis was conducted using an iterative approach in which MADs’ individual behavioural differences during their interactions with the controls served to highlight tail wagging behaviour as a valid parameter to measure their emotional states.

6.1.1 Participants

Participants in the study included three MADs. Two were black Labrador cross Golden Retrievers, one male (Odin, born March 2016, in his 7th week of training) and one female (Lucy, born September 2016 and in her 9th week of training); and one was a male Golden Retriever (Zion, born September 2016 and in his 9th week of training). All participants were screened to have reached a level of fluency in executing a “nudge” command. Human participants included two full time trainers, T1 being responsible for Lucy and Zion and T2 being responsible for Odin.
6.1.2 Methodology

The study took place on June 11th, 2018, in DFG’s main training room, which was outfitted with a motorized door that was opened with a SIAC. Data was collected from two sources. The first, was the recording of a series of training sessions in which the three MAD participants were observed executing a “nudge” command while interacting with a SIAC; and the second was the completion of the MCPQ-R questionnaires - which due to their experience with assessing canine behaviour and their knowledge of the individual MADs - were given to the dogs’ trainers to complete. The training sessions lasted approximately 10 to 15 minutes and consisted of a series of individual trials defined as the time between when the command was first issued by the trainer, and the time when the MAD had been rewarded for successfully opening the door, or, if unsuccessful, the moment the trainer terminated the trial - giving the dog a few moments to recover before re-issuing the command and starting a new trial. Most trials lasted approximately between 3 and 120 seconds. A trial which lasted longer than 120 seconds was most likely to be terminated by the trainer to prevent the dog from experiencing frustration or loss of confidence. Most trials observed lasted between 3 and 30 seconds and, if successful, ended with the dogs being primarily given food-based rewards or in some cases, verbal (e.g. “good lad”) or physical (e.g. petting) rewards.

To the best of my knowledge, there was no established method for evaluating MADs’ affect-based interactions with devices while carrying out operational commands. Thus, informed by our previous investigation of MADs behaviours and methods proposed by previous ACI studies, we developed an approach to measuring and interpreting MADs’ states during their interaction with technological devices, in this case a standard issue access control (SIAC). The method was developed adopting a grounded theory approach and led to a total of six iterations, which are described in the following section. As in the previous study, I collaborated with Elizabeth Cox, in the data collection and analyses. Our collaboration is indicated by the use of the pronoun we in the following sections.
6.1.2.1 Iteration 1 – Capturing Fast Occurring and Nuanced Behaviours

My first approach to analyzing the video involved reviewing the footage at a (1:1) playback speed using QuickTime Player V. 10.4 software. Doing so, enabled me to define an initial list of codes to categorize MADs’ and their trainers’ general behaviours (Appendix 8). However, when examining the types of behaviours captured, I realised that the 1:1 playback of the footage did not allow for the detailed observation or coding of all of the MADs’ behaviours, specifically those which were fast-occurring or nuanced. To check if this was the case, I reviewed the footage a second time using a 1:2 playback speed. Indeed, this time I was able to code a wider range of behaviours which had previously remained undetected; however, the process resulted in a significant increase in the amount of codes generated (from 11 to 42), and thus the amount of time needed to review the video, and the amount of data produced. Due to the time and resource constraints during this PhD, I determined that in order to carry out the analysis of the data to the degree of detail required for the accurate interpretation of MADs’ behaviours, I would need to optimize my approach.

6.1.2.2 Iteration 2 - Optimizing the Behavioural Coding Process

The second attempt was informed by techniques commonly used in thematic data analysis, an axial coding exercise. Given its systematic approach to “fleshing out categories and relating them to their subcategories” (Corbin and Strauss 2014), it allowed me to group the code list into themes which made it easier to discern which codes applied to behaviours that would help me to evaluate MADs’ experience and which codes could be eliminated. The results of the exercise reduced the number of codes from 42 to 27 and included the following themes (Table 3):

1. MADs’ General Behaviours: codes associated with MADs’ general behaviours (e.g. DME: MAD moves ears)
2. MADs’ Interactive Behaviours: codes associated with MADs’ behaviours while interacting with the SIAC (e.g. DNC: MAD approaches control without contact)
3. Trainer Behaviours: codes associated with the trainers’ general behaviours (e.g. TMC: trainer moves towards control)
4. Other Events: codes associated with other events (e.g. DO: door opens)
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>1. General Behaviours</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>DSIT</td>
<td>MAD sits</td>
</tr>
<tr>
<td>2</td>
<td>DLAY</td>
<td>MAD lays down</td>
</tr>
<tr>
<td>3</td>
<td>DJ</td>
<td>MAD jumps</td>
</tr>
<tr>
<td>4</td>
<td>DA</td>
<td>MAD approaches control</td>
</tr>
<tr>
<td>5</td>
<td>DP</td>
<td>MAD uses paw to activate control</td>
</tr>
<tr>
<td>6</td>
<td>DSN</td>
<td>MAD uses snout to activate control</td>
</tr>
<tr>
<td>7</td>
<td>DWT</td>
<td>MAD wags tail</td>
</tr>
<tr>
<td>8</td>
<td>DTT</td>
<td>MAD tucks tail</td>
</tr>
<tr>
<td>9</td>
<td>DMEF</td>
<td>MAD moves ears forward</td>
</tr>
<tr>
<td>10</td>
<td>DMEB</td>
<td>MAD moves ears back</td>
</tr>
<tr>
<td>11</td>
<td>ODB</td>
<td>Other MAD behaviour</td>
</tr>
<tr>
<td>12</td>
<td>DLL</td>
<td>MAD licks lips</td>
</tr>
<tr>
<td>13</td>
<td>DCW</td>
<td>MAD comes into contact with the wheelchair</td>
</tr>
<tr>
<td>14</td>
<td>DSA</td>
<td>MAD sniffs air</td>
</tr>
<tr>
<td>15</td>
<td>DSF</td>
<td>MAD sniffs floor</td>
</tr>
<tr>
<td>16</td>
<td>DS</td>
<td>MAD shakes</td>
</tr>
</tbody>
</table>

| **2. Interactive Behaviours** |   |   |
| 17 | DLT | MAD looks towards trainer |
| 18 | DLC | MAD looks towards control |
| 19 | DLD | MAD looks towards door |
| 20 | DLTB | MAD looks towards treat bag |
| 21 | DLTH | MAD looks towards trainer’s hands |
| 22 | DLA | MAD looks away from the door and trainer |
| 23 | DRP | MAD uses right paw to activate control |
| 24 | DLP | MAD uses left paw to activate control |
| 25 | DNC | MAD approaches control but does not make contact |

| **3. Trainer Behaviours** |   |   |
| 26 | OTB | Other trainer behaviour |
| 27 | TDA | Trainer gets dog’s attention |
| 28 | TINC | Trainer issues “nudge” command |
| 29 | TIPC | Trainer issued “push” command |
| 30 | TMC | Trainer moves towards control |
| 31 | TMW | Trainer moves wheelchair |
| 32 | TGVR | Trainer gives verbal reward |
| 33 | TGRF | Trainer gives food reward on floor |
| 34 | TGRH | Trainer gives food reward in hand |
| 35 | TIC | Trainer issues command |
| 36 | TPC | Trainer points towards control |
| 37 | TLC | Trainer leans towards control |
| 38 | TGR | Trainer gives reward |

| **4. Other Events** |   |   |
| 39 | DDO | Door does not open |
| 40 | DO  | Door opens |
| 41 | GTD | Trainer and MAD go through door |
| 42 | RA  | Researcher appears in video |

Table 3: Themed code list (grey cells indicate the eliminated codes)
In order to test the validity of the optimized code list, five sessions were recoded, and the results of their analysis compared to those of when they had been coded using the initial code list. Comparing the results indicated that the optimized code list still provided enough behavioural data to accurately evaluate MADs’ interactions while significantly reducing the time needed to code the videos.

6.1.2.3 Iteration 3 - MADs’ Interactions with an Access Control as a Task Sequence

Although the optimized code list and the use of the QuickTime software provided a good approach to analyzing the footage, I investigated other software which would be easier to use and provide a more targeted approach to video analysis. I identified ObjectusVideo V.1.0.2, a motion video analysis software that allows the playback of video at reduced speeds, the use of drawing tools to annotate the video, and the ability to label events on a frame by frame basis. Using the labels applied to the video, the software captures a snapshot of the footage and produces a visual action sequence which can then be exported in PDF format. To test the software, I coded 31 trials and reviewed their resulting visual action sequences (Figure 16).

![Figure 16: “Nudge” trial action sequences](image)

The sequences revealed a common pattern of occurrence across the trials which began and ended after specific behaviours had been carried out by MADs and their trainers. Patterns of occurrences such as these, are what interaction designers commonly refer to as task sequences and are usually pre-defined and used during task analysis (§3.3.4.3). Because I was using a grounded theory approach to measuring MADs’ behaviours, the analysis of the trials was not based on a predetermined “nudge” task sequence; rather, it was based on the definition of a task sequence resulting from the
emergent behaviour patterns. Thus, MADs’ behaviours were grouped into the following tasks which included activities related to:

1) **Start** – Gaining the MAD’s attention before executing the command. For example, by the trainer issuing a “ready?” prompt which caused the dog to become alert.

2) **Attempt** – Prompting the MAD to operate the SIAC including the issue of the “nudge” command by the trainer and their support of the dog throughout.

3) **Reward** – Rewarding the MAD for successfully executing the command.

By defining a task sequence for MADs’ interactions with the SIAC, I was able to contextualize MADs’ and their trainers’ behaviours to the specific activities being carried out. This allowed me to better understand the implications of the coded behaviour based on when in the sequence it had occurred. For example, if a trial was described by a high number of DLT codes (MAD looks towards trainer) during the Start task, this would potentially imply that the MAD was waiting for the trainer to begin the trial, or if a high number of codes was used to describe the Attempt task, this might imply the MAD was looking for guidance from the trainer as to how to interact with the control.

The coding process was made more efficient by rearranging the codes based on the likelihood of when they would be exhibited during the task sequence, a change which reduced the number of potential codes that might need to be referenced during video analysis and which quickened the coding process (Appendix 9).

### 6.1.2.4 Iteration 4: - Addressing A Coding Bias

When reviewing the coded videos from the previous iteration, it became apparent that I had coded the trainers’ behaviour to a higher degree of detail than the MADs’. This was likely a product of my role as a human researcher coding on behalf of another species, and to my familiarity with coding human behaviour. The presence of coding biases in behavioural analysis is not an uncommon issue, with many approaches to addressing biases available in the literature (Preece, 2015). To address my bias, I applied a viewing hats technique (§3.3.2.2), whereby by adopting a specific viewing hat during data analysis I was able to explicitly and intentionally adopt a different perspective. In particular, I defined three viewing hats including from the perspective of a MAD, a MAD trainer, and a user-centred designer.
The MADs’ perspective viewing hat is arguably impossible to adopt as a human, a circumstance previously discussed in §5.1.4; and which here is addressed by implementing a set of prompts to guide the coding of the data and to support the explicit and intentional nature of the approach. The purpose of the prompts was to act as guides throughout the coding process and provide me with points of reference for the MAD perspective when coding the data. For simplicity, prompts were formulated using a first-person point of view from the MAD’s perspective. They included:

1) “If the trainer was the only source of guidance as to what my actions are supposed to be, was their behaviour clear, consistent, and easy for me to interpret?”
2) “Is my behaviour consistent with what I am being asked to do, or is my behaviour seemingly communicating something different?”
3) “If this was the first time I had encountered this experience, how - if at all - would I be influenced by the humans and artefacts present during the interaction or the environment in which the interaction took place?“.

The MAD trainer viewing hat perspective was a result of my previous certification as a MAD trainer, and focused on behaviours which specifically related to the execution of the commands including the timing and manner in which the commands were issued, the timing and type of rewards, and the number of attempts made by the dog to activate the SIAC. The third viewing hat was from the perspective of a User Centered Designer, which based on my previous experience within industry I was qualified to adopt. It focused on behaviours which the MADs and trainers performed while interacting with the artefacts (i.e. access control, wheelchair, door, floor), the environment (i.e. lighting and ambient noises), and themselves (e.g. looking towards each other). The viewing hats technique was used to code 42 trials, with each trial reviewed three separate times adopting one viewing hat each time. Based on the results of this analysis, I deemed the viewing hats technique a valuable tool to apply when investigating MADs’ behaviours.

6.1.2.5 Iteration 5 – Defining the Essential Activities of MADs’ Interactions

Defining a task sequence reduced data analysis time; however, applying the viewing hats technique significantly increased it; hence, in order to benefit from the use of the
viewing hats technique within the available time, I explored other approaches commonly used by interaction designers faced with similar challenges. Since MAD’s use of a SIAC involved a fairly simple interaction, I considered the use of essential use cases (§3.3.4.3) - which describe the single use of a system from the user’s perspective - a viable approach. I expected that the essential nature of such a use case would inform my understanding of the interactions between MADs and the SIAC while reflecting MADs’ perspective and containing the potential of a coding bias. Figure 17 shows the essential use case developed for MADs’ execution of the “nudge” command while interacting with a SIAC.

![Image of essential use case](image)

Figure 17: Essential use case for a MADs’ interaction with an access control

To test its application, data from the videos was recoded using a Data Analysis Matrix (Figure 18) which comprised the following sections:

- **Trial Data**: file name, trial synopsis, trial duration, whether the trial was successful or unsuccessful, and the observed level of support provided by the trainer.
- **Participant Data**: the participants’ identifiers and their MCPQ-R scores
- **Data Analysis Matrix**: presented the essential use case on its vertical axis and the trial’s duration in seconds on the horizontal axis. To populate the matrix, behavioural codes were plotted into cells according to when they occurred and
whether the behaviour observed had occurred as a part of a user action or system response. Then, the cells were colour coded based on which user had exhibited the behaviour: MADs (blue), trainers (yellow), or both (green).

- **Comments**: section used to record any critical incidents during the trial.

A total of 10 trials were coded using the matrix, **supporting a data analysis process which was quick, clear, consistent, and systematic.**

![Figure 18: Data analysis format](image_url)

### 6.1.2.6 Iteration 6: The Tail Wagging Ethogram

The final iteration of data analysis aimed to feed into a method to inform our understanding of MADs’ affective states during their interactions with a SIAC. Methods commonly applied by researchers to measure animals’ states include measuring salivary cortisol, heart rate variability and oxytocin levels. Although seemingly effective, data collection for these methods is highly invasive for the animal user, which is contrary to the tenants of ACI, and which can potentially compromise the reliability of results. Hence, none of these methods were chosen. Following reflections regarding alternative non-invasive approaches among the research team, we identified the dogs’ tail wagging behaviour as a possible parameter to investigate. **This was due to tail wagging being a naturally occurring, overt, and explicit form of communication and indicator of a dog’s state** (Handelman, 2012, Siniscalchi et al., 2010, Kleiman, 1967, Bradshaw, 2011). When reviewing the existing literature on tail wagging, Cox and I found that different tail positions or wagging directions (left vs right) could communicate different states...
depending on the duration and intensity of the wag (Handelman, 2012, Siniscalchi et al., 2010, Kleiman, 1967, Bradshaw, 2011). For example, Kleiman (1967) and Bradshaw (2011) studied wild and domestic dogs respectively, finding that low tucked-in tails show a lack of confidence as well as submission, that upright tails with a wagging tip show interest, and that relaxed tails with a moving back-end indicate excitement and a desire to play. Tail wagging behaviour has been used as a parameter in a number of different studies; for example, by observing tail carriage, Beerda et al. (1996) found that high cortisol and a low, or very low posture, with a tail in either a low position or curled forward between the hind legs, was indicative of acute stress. Leaver and Reimchen (2008) observed that tail length was an important factor in canine communication and that long tails are more communicative than docked tails. Quaranta et al. (2007) found that dogs wagged their tails more to the right when exposed to positive stimuli and to the left when exposed to unfamiliar or neutral stimuli. McGowan et al. (2014) observed an increase in tail wagging frequency in dogs that were successful in problem solving in order to obtain a food reward. Travain et al. (2016)’s research found that tail wagging frequency also increased during a food reward phase. Overall, these studies show tail wagging as an important parameter which could assist in understanding how dogs communicate their pleasure or satisfaction with an interaction, as well as displeasure or dissatisfaction.

To my knowledge, there is no standardized method to measure tail wagging behaviour; thus, informed by the research presented above and by frameworks commonly used within the disciplines of animal behaviour science and ACI, an ethogram for the standardized observation of dogs’ tail wagging behaviour was developed. Ethograms are frameworks used by animal researchers that list a series of behaviours exhibited by a species, which can then be used as a measure of the animals’ reaction to specific stimuli (Martin et al., 1993), in this case their interaction with the SIAC. The Tail Wagging Ethogram (Figure 19), included the following tail wagging parameters: tail position, described as high, horizontal or low; tail direction, described as left, centre or right; tail angle, described as 90° , 45° or <45° ; and tail tip angle, described as 90° , 45°, or <45°. Additionally, tail wagging frequency (number of wags) was also recorded.
In order to apply the ethogram in a way that would not significantly increase the time required to record MAD’s tail wagging behaviours, tail wagging observations were recorded based on the essential use case developed in the previous iteration, and which included two distinct phases. The first phase identified as the before phase accounted for MADs’ tail wagging behaviours from the moment the command was issued by the trainer to the time when they made their first contact with the SIAC. The after phase accounted for MADs tail wagging behaviour immediately after the first contact with the SIAC had been observed, continued during the dogs’ interaction with the SIAC and ended when the dog had either pushed the SIAC using their snout or had returned all four paws to the floor.

The phases were identified based on the assumption that MADs’ state would change before and after coming into contact with the control. Although no states were preemptively defined, we assumed that due to the dogs’ previous training experience, and their familiarity with executing a command in exchange for a reward, states such as alertness, excitement, and anticipation might be observed. Then, once the command had been issued and up until they came into contact with the SIAC, other states such as confusion or lack of interest might also be exhibited; with the latter, having been observed during previous trials. Additionally, during the after phase, if the first contact
with the SIAC had not resulted in the door opening, states such as frustration or hesitation might also be observable. 

**Based on the method’s development process described above, we were confident that a first version of the ethogram would provide a level of approximation sufficient to evaluate MADs’ affect-based interactions with the SIAC in an individualized, consistent, unambiguous, unbiased, and non-invasive manner.** However, the use of the ethogram continued to require a significant amount of time, therefore we focused the verification of the method on 18 trials that contained both successful and unsuccessful attempts and clear footage of the MADs tails throughout. These were viewed using frame by frame analysis on Windows Movie Maker (V8.0.2.0) which, given the speed of tail movement, was essential to understanding the nuances of tail wagging. Results were recorded in a Microsoft Excel file.

### 6.1.3 Findings

Findings revealed commonalities among participants’ personality traits that are considered critical for MADs, such as amicability, and training and focus. They also revealed individual differences in other traits, such as neuroticism, extraversion and motivation. In addition, tail wagging behaviour emerged as a good measure of MADs’ affective states when interacting with a device due to its analysis confirming that through their individual tail wagging behaviours, the dogs were exhibiting different affective states during their interactions with a SIAC. The following sections discuss these findings in detail.

#### 6.1.3.1 MCPQ-R Questionnaire Results

Participant MCPQ-R results (Figure 20) evidenced all dogs obtaining high scores in regard to traits which are usually sought out in assistance dogs, with Odin scoring 77.8% and Lucy and Zion sharing an 86.1% score in regard to **training and focus**; and Odin scoring 80%, Lucy at 83.3% and Zion at 86.7% with regard to **amicability**. In terms of extraversion, Odin scored the highest (77.7%), with Lucy a close second (67.7%) and Zion, further down the scale at 44.4%. Odin scored the highest in **motivation** 80%, with Lucy and Zion further down the scale with 66.7% and 63.3% respectively. Finally, in
terms of neuroticism Zion scored the highest at 54.2%, followed by Lucy at 45.78% and Odin at 29.2%.

![MCPQ-R Participant Results](image)

Figure 20: Participants’ MCPQ-R scores as assessed by their trainers

6.1.3.2 MADs’ Tail Wagging Behaviour while Interacting with an Access Control

Video analysis of MADs’ interactions with a SIAC revealed an observable change in their tail wagging behaviour in terms of the frequency, direction, angle, and position of their tails between the before and after phases of each trial; changes which seemed to correspond to changes in state such as anticipation, excitement, confusion, and frustration. Furthermore, an individual change in tail wagging behaviour was observed with regards to trials during which the dogs had either failed or succeeded in executing the “nudge” command (where success was based on the door opening).

The Before Phase

During the before phase, MADs’ tail wagging behaviour seemed to signal a state of anticipation, with some of their specific tail wagging behaviours corresponding more so to the state itself. For example, among the participants, an overall low frequency of tail wagging behaviour was observed (Zion = 3, Lucy = 10 and Odin = 12), which could be argued was a result of MADs having a lower baseline arousal before a command was issued compared to that of pet dogs (Helton, 2009, Bergin, 2012) (Figure 21). In comparison, when it came to the MADs’ direction of tail wagging, participants showed
a slight preference towards the right (right = 11; left = 8), consistent with the anticipation of a positive stimulus (Quaranta et al., 2007).

In terms of the angle of the tail (Figure 22), participants showed a greater number of 90° tip wags (7), as opposed to 90° wags (3). This difference in angle might be due to the dogs being slightly aroused before the trial, probably in anticipation of the command being issued. With regards to the MADs tail position, it could be argued that Lucy was in a state of confident anticipation for the trial to begin, tending towards a high tail position (31 instances) rather than a horizontal tail position (7 instances) or low tail position (4 instances). A state of confident anticipation for Lucy was consistent with her high scores for training and focus (86.1%) and extraversion (67.7%), both traits relating to a dog’s sense of confidence (Handelman, 2012). Odin showed a tendency towards a high tail position (21 instances), followed closely by a horizontal tail position (17 instances) with almost no low tail positions (1 instance). Similar to Lucy, Odin’s tail position could be related to his high score for extraversion (77.7%) and possibly his score for motivation (80%) which would indicate a state of anticipation prior to the trial. Zion mostly kept his tail in a horizontal or low position (16 instances respectively) while only occasionally exhibiting a high tail position (9 instances). Zion’s breed could have influenced his tail position as well as his slightly higher score for neuroticism (54.2%); a trait which had been discussed by the trainers as being prevalent in Golden Retrievers.
The After Phase

During the after phase, MADs’ tail wagging behaviour more evidently evidenced a state of excitement, most likely due to the dogs having completed the harder part of the interaction and expecting a food reward, which has been known to elicit pleasant emotions and responses in dogs (Serpell and Barrett, 2017). For example, all dogs had increased tail wagging frequency during the after phase (Zion = 41 wags, Odin = 39 and Lucy = 42, for a total of 122 wags) as opposed to during the before phase (25 wags total). The increase in tail wagging frequency could be a result of arousal (McGowan et al., 2014) due to the dogs anticipating the reception of the reward, trying to get the trainer’s attention to prompt the reward, or being confused by the delay in receiving the reward. All three causes possibly related to the observed variability in the time taken by the trainers to issue the rewards, which ranged anywhere between 3 and 5 seconds or in some instances even longer due to the trainer moving away from the control before issuing the reward.

The after phase did not reveal any significant differences in tail wagging direction (Figure 23), resulting in an almost equal split (57 wags towards the left and 56 towards the right), which seems to correspond with the dogs being fluent in executing the command and knowing what to do. In terms of the angle of the tail during tail wagging, participants showed a greater number of 90° wags (47), as opposed to 90° tip wags (27). This increase in angle could be attributed to their increase in arousal levels as a result of their anticipation of receiving a reward, or their excitement of having been rewarded, a state previously observed by McGowan (2014) and Travain (2016).
In terms of tail position (Figure 24), all dogs exhibited a somewhat close number of instances in terms of their tail positions with Odin exhibiting 3 instances in high position, 3 instances in low position and 7 instances in a horizontal position; Lucy exhibiting 5 instances in a high position, 2 instances in a horizontal position and 3 instances in a low position; and Zion exhibiting 1 instance of high and horizontal tail positions and 1 instance of a low tail position. As with tail direction, it could be argued that, although the dogs were in expectation of the reward, having executed the command resulted in a more relaxed state.

6.1.3.3 Failed Attempts

Failed attempts were defined as those in which the MAD came into contact with the SIAC but did not manage to activate the door resulting in a trial were a reward was not issued. Discussion of the MADs’ tail wagging behaviours during failed attempts seemed to reveal a distinction between the awareness of failure between the MADs, and their
trainers. For the dogs, the trial seemed to have been successful by coming into contact with the control regardless of the door opening, evidenced in part, by all participants mostly focusing on the trainer’s reward bag or on the trainer after having come into contact with the SIAC. For the trainers, success and failure were clearly differentiated based on the door opening or remaining closed. This is mostly due to the dogs being fluent in executing the nudge command, because if they had been in at an earlier stage of learning (§5.2.3.1), the trainers’ definition of success might have been similar to that of the dogs. For example, after a failed attempt, Lucy, who had the lowest number of failed attempts, showed what could be considered distraction or displacement behaviour by turning away in the opposite direction after having come into contact with the control but not receiving a reward. Her tail wagging during this period remained high, but she showed more 45° wagging (11 wags) than 90° wagging (8 wags). The behaviour and the difference in tail angle and direction could indicate that Lucy was under stress at this time. In contrast, Zion spontaneously activated the control 4 times even though he had not been issued the command. Zion scored more highly on training and focus with 86.1%, so this behaviour could indicate his attempt to induce his trainer in issue him more food rewards with spontaneous control pushes, regardless of their success or failure (Figure 25).

![Figure 25: MAD participants' tail position after failed and successful attempts](image)

6.1.3.4 Tail Wagging as an Individual Characteristic

Overall, tail wagging behaviours in regard to position, direction and angle were characteristic to each participant, showing differences between the three dogs. Odin’s
Tail wag tended towards a high (46%) and horizontal (46%) tail position, with a preference towards right sided wags (55%), an angle of tail movement at 90° (41%) and a 90° tail tip movement (33%). Lucy’s tail wagging notably tended towards a high position (69%), with a fairly equal preference for wagging to the left (46%) and right (42%), and with a preference (33%) towards a 90° angle. Zion’s tail position exhibited an equal preference between a horizontal (38%) and low (41%) position, a tendency towards a left-sided wag (48%) rather than right-sided (40%) and midline-sided (10%) wags, and an angle of tail movement at 90° (41%) or a 90° tail tip movement (36%). Figure 26 illustrates the tail wagging ethogram used to describe the participants’ individual tail wagging behaviours.

![Figure 26: MAD participants’ individual tail wagging ethograms](image)

6.1.3.5 Tail Wagging and Personality

Participants’ individual tail wagging behaviours seemed to correlate to their personality scores. In the case of Odin, it is interesting to note that having scored higher on extraversion (77.8%) he exhibited a greater number of tail wags in the high and horizontal position (92%) and to the right (54%). He also showed consistent 90° wagging of the whole tail or of the tip (74%), behaviour which Svartberg and Forkman (2002) found to be consistent with that of confident dogs. In contrast, Zion scored more highly on neuroticism and showed consistent 90° wagging of the whole tail or tip (77%) but with his tail in the horizontal or low position (77%), which could indicate lack of confidence and submission (Bradshaw, 2011, Kleiman, 1967) or could be a breed-
specific trait to Golden Retrievers (Handelman, 2012). Lucy scored mid-range for both extraversion and neuroticism. Of the three dogs she showed the greatest variation in the angle at which her tail wagged 44% of her wags were full or tip 90° wags, 22% were at an angle of 45° and 35% were at an angle of <45° (tip and full). However, her tail position was predominantly high (69%) and she showed a fairly equal preference for wagging her tail to the left and right (L:46%, R:42%). These findings could indicate that tail wagging at an angle of 45° or <45° (tip or full tail) might show uncertainty in a dog who is both confident and submissive.

6.1.4 Discussion

With this study we explored the validity of a method of observing dogs’ tail wagging behaviour as a means to evaluate and measure MADs’ states during their active interactions with a SIAC; which based on these findings, is proposed as an accurate and individualized method for assessing MADs’ affective states while interacting with a technological device. The following sections discuss the findings and provide suggestions towards improving the approach.

6.1.4.1 Constraints of Behavioural Research

Even though integrating the essential use case of MADs’ interaction with a SIAC helped disambiguate the coding process, the analysis process remained resource and time-consuming, and generated a significant amount of data. This is not an uncommon circumstance when analyzing behaviour and seems to begin to emerge as a common theme throughout the research. Although recent research within ACI has been investigating methods to automate this type of analysis (Roberts et al., 2019), we propose that any time-savings during analysis should be measured against the accuracy of the results. There is a lot we still do not understand about the way animals interact with technological devices; thus, it is important that developing more efficient and faster methods of analysis does not compromise the validity of the results, or the ability of the researcher to assess the animals’ behaviour in a fair, consistent and accurate manner.
6.1.4.2 The Influence of the Researcher

Similar to the influence exerted by stakeholders on the MADs’ UX, here it is the influence of the researcher on the assessment of the animals’ behaviour during research that emerges as critical. This is due to the reliance on the researchers’ ability to correctly analyse and thus assess and evaluate their behaviour. Their ability to do so is dependent on their knowledge and experience of interacting with the animal and observing their behaviours, an ability which is arguably impacted by their background. For example, my background is in human centered design, and I, prior to the research, had studied dogs and learned to train MADs’; therefore, I was able to use my previous experience when evaluating MADs’ interactions with the SIAC. However, if my background had not been within a field that had prior knowledge related to carrying out a form of user research (e.g. anthropology, psychology, design or others in which practitioners learn about observing human behaviour), or working with animals (e.g. biologist, ethologist, veterinarian or others in which practitioners learn about animal behaviour) the amount of knowledge I would have had to accrue prior to the research would have been greater. Yet, even with my previous knowledge I exhibited a coding bias. The above by no means aims to imply that practitioners that are outside the types of fields described cannot conduct ACI research; it does, however, aim to highlight is that it is not only as users of interactive devices that the animals’ UX should be considered; but also, as participants within ACI research. Hence, methods such as the viewing hats technique could potentially be applied not only as a means to overcome a potential researcher bias within the research, but as a tool that ACI practitioners could apply to help them determine the potential gaps in knowledge regarding the animal user, specifically regarding the assessment and evaluation of their behaviour that need to be addressed. Adopting various viewing hats, and possibly including one of a researcher’s belonging to a discipline more akin to ACI might help to ensure that the animals’ behaviour is correctly assessed and thus their UX as a research participant is considered.

6.1.4.3 The Influence of the Reward

The use of rewards by human stakeholders is a common practice during MAD training and assistance work, to the extent that MADs seem to expect a reward after completing a task, whether that be in the form of food or praise. Furthermore, the data evidenced
rewards to be highly motivating for the dogs, with some participants focusing most of their attention on the trainer’s reward bag over the door itself, and others (e.g. Odin) continuing to come into contact with the SIAC, seemingly in the hopes of obtaining more rewards. However, the MADs’ and trainers’ understanding of what success means seems to differ; MADs’ understanding of success seems to be the coming into contact with the SIAC irrespective of the door opening, while the trainers’ understanding of success involves the door opening. Therefore, it could be hypothesized that obtaining a reward before the door opened or even if they were not aware that the door did open, could confuse the dogs, thus impacting on their association of the rewards’ meaning as success. Perhaps the reward could be taken out completely; however, removing any and all types of rewards would seemingly go against the tenets of partnership between MADs and humans, and more importantly make the process of learning more difficult for the dogs. Another alternative might be to delay the reward until after the door had opened and the threshold had been crossed, or the door itself could communicate success to the dog through a specific sound, or possibly offering the reward itself. 

Whatever the specific solution might be, it is important to note that in order to afford MADs’ a good UX, both trainers and the dogs should have a shared understanding of what success means and that the device with which the dog is interacting, should present the dog with clear feedback on the success or failure of the interaction.

6.1.4.4 MCPQ-R

Findings supported the MCPQ-R personality questionnaire to be a reliable tool to measure canine personality. However; although the personality traits the MCPQ-R takes into account have in fact informed our understanding of MADs’ behaviour they do not include other traits which could potentially improve the understanding of specific MAD behaviours during their interactions with technological devices. For example, findings from the studies carried out in Chapter 5 included comments made by trainers and other DFG staff which revealed other traits as potentially interesting to consider when evaluating MADs’ interactions, including traits such as confidence, perseverance and openness to novel stimuli. Because the use of interfaces by canine users remains a novel area of study, personality evaluations which relate to traits such as these have yet to be researched, leaving a significant area of study open to further inquiry.
6.1.4.5 Tail Wagging as a Baseline to Measure MAD Behaviour

The above findings suggest that tail wagging is a measurable behavioural parameter which, when observed in detail against individual behavioural characteristics, provides valuable information towards understanding and potentially measuring MADs’ state during their interactions with technical devices. Furthermore, because of its’ individual nature, the measure of a dog’s tail wagging behaviour while engaged in different activities (e.g. task work or play), or activities similar to the interaction being investigated could potentially be used to establish individual behavioural baselines so that when their behaviour is assessed during the specific interaction, it could be further contextualized to their nature. For example, considering the individual MAD tail wagging ethograms presented in Figure 26, if these had been established prior to the study, we could have used them as a means to calibrate the dogs’ tail wagging behaviour during their interactions with the SIAC. Doing so would have most likely allowed us to deepen our understanding of the nuanced nature of MADs’ states throughout the interaction; because although we were able to measure the occurrence of the state itself, we did not, for example, measure their duration or frequency. Knowing these parameters could have revealed more nuanced changes in the MADs’ exhibition of the state throughout the interaction, allowing us to identify those which might be considered regular, irregular or critical. For example, states related to arousal, such as those of anticipation and excitement are both known to be common to carrying out task work; however, arousal is known to be a state that can quickly change from a positive connotation to a negative one (§4.3.2.2); hence, knowing a dog’s baseline tail wagging behaviour could help determine when this change in connotation happens and result in a better understanding of their UX while interacting with the SIAC.

6.1.4.7 The Need for a Comprehensive Understanding of MADs’ UX

Although the previous study produced methods which enabled us to gain an understanding of MADs’ affect-based interactions during their use of a SIAC, we remained unaware of the effect the control’s usability had on their UX. The need to comprehensively evaluate MADs’ UX is an important aspect of our research, hence for the next study we focus on previous approaches used by ACI researchers to analyse
animal behaviour in relation to objective usability measures as a means to investigate MADs’ use of devices.

6.1.5 Study Limitations

This study is a first attempt at validating a tail wagging ethogram as a method for measuring MADs’ affective states during their interactions with a technological device; however, due to the small participant sample size (3 dogs), the extent to which the method was validated remains limited. To further verify the validity of the approach, tail wagging behaviour should be observed within a larger participant sample; including dogs of different breeds and training backgrounds. A result which would likely lead to a wider range of personalities and different types of tails to be considered. Furthermore, because measuring MADs’ tail wagging behaviour emerged during data analysis; the initial recording of MADs’ interactions with the SIAC although providing a clear view of their tails did not provide the best possible angle from which to observe their tail wagging behaviour. Hence, for future studies an improved approach to the recording MADs interactions should be taken, including for examples footage from various viewpoints. Additionally, although the current parameters included in the tail wagging ethogram seem to accurately support the measurement of MADs’ affective-states other parameters remained unexplored - such as those of tail wagging speed and the specific part of tail that was wagged - as these have also been proven to be indicative of affective states. Furthermore, as previously mentioned the influence of rewards on MADs’ interactions is significant, hence future studies could consider the measure of emergent behavioural patterns to shed insight on the possibility of separating the reward, either verbal (e.g. “yes!”), food-based, or physical (e.g. petting), in current operant conditioning training techniques; or conversely investigating using rewards not only as a marker of success but as a means to increase the potential for the dogs’ understanding of the task.
6.2 Investigating MADs’ Usability-Based Interactions

In order to contribute to our assessment of MADs UX while interacting with technological devices, this study applied a Method for Evaluating Animal Usability (MEAU) whose development was informed by a combination of methods from ACI, ID and approaches from the previous study. The method was applied in a comparative usability study in which nine MADs where observed carrying out a “nudge” command while interacting with two types of access controls; a SIAC and a set of canine-friendly access control prototypes which had been previously developed by Mancini et al. (2016). Findings included a heuristic evaluation of the controls’ adherence to interaction design principles and an empiric evaluation of their usability which were used to further define a set of emergent MAD user requirements. The following sections describe the study in detail.

6.2.1 Participants

MAD study participants included nine dogs nearing the end of or having finalized their training (Figure 27), of which six were males and three were females, with a mix of breeds including six Golden and Labrador retriever crosses, two Labrador retrievers and one Labradoodle. Human participants included three DFG full time trainers, each being responsible for three MADs.

<table>
<thead>
<tr>
<th>ID</th>
<th>Breed</th>
<th>Age (months)</th>
<th>Sex</th>
<th>Coat Colour</th>
<th>Trainer</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Golden Retriever German Shepard cross</td>
<td>21</td>
<td>F</td>
<td>Golden</td>
<td>T1</td>
</tr>
<tr>
<td>D2</td>
<td>Golden and Labrador Retriever cross</td>
<td>16</td>
<td>M</td>
<td>Black</td>
<td>T1</td>
</tr>
<tr>
<td>D3</td>
<td>Golden and Labrador Retriever cross</td>
<td>16</td>
<td>M</td>
<td>Black</td>
<td>T1</td>
</tr>
<tr>
<td>D4</td>
<td>Golden and Labrador Retriever cross</td>
<td>19</td>
<td>F</td>
<td>Black</td>
<td>T2</td>
</tr>
<tr>
<td>D5</td>
<td>Labradoodle</td>
<td>17</td>
<td>M</td>
<td>Black</td>
<td>T2</td>
</tr>
<tr>
<td>D6</td>
<td>Golden and Labrador Retriever cross</td>
<td>19</td>
<td>M</td>
<td>Golden</td>
<td>T2</td>
</tr>
<tr>
<td>D7</td>
<td>Labrador Retriever</td>
<td>19</td>
<td>M</td>
<td>Golden</td>
<td>T3</td>
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<tr>
<td>D9</td>
<td>Labrador Retriever</td>
<td>23</td>
<td>M</td>
<td>Golden</td>
<td>T3</td>
</tr>
</tbody>
</table>

Figure 27: MAD participant demographics

6.2.2 Method for Evaluating Animal Usability (MEAU)

The method used in this study comprised a series of eleven steps aimed to systematically understand, measure, and evaluate animals’ interactions with technological devices. It involves a combination of approaches for understanding
animal user interactions, including methods applied in the previous study; human-centric approaches adapted for animal use, and usability-based evaluation approaches from previous ACI research (§2.4 -specifically the work of Byrne et al., 2017, Jackson et al., 2015 and Zeagler et al., 2014) The method’s steps are depicted in Figure 28 and described in the following sections.

6.2.2.1 Step 1 - Understanding the Interaction

In order to identify aspects of the animals’ interactions with devices that are relevant to measure usability, I begun by systematically describing the interaction under investigation. Depending on the complexity of the interaction, other methods might have included hierarchical task analysis, however, due to the simple nature of MADs interactions with the SIAC and the similarity of the prototypes to it, the previously developed essential use case for MADs interactions with access controls (§6.1.2.5) was applied.
6.2.2.2 Step 2 - Identifying Relevant User and System Characteristics

In order to identify the relevant user characteristics needed for a successful interaction and gain a detailed understanding of the specific actions carried out by the user and the system during the interaction -albeit focused on humans - Hekkert and Schifferstein (2008)'s model of user-product interaction (§2.2.5) provided a comprehensive framework. By considering the access control as the system, working through the model enabled the systematic definition of the capabilities that MADs would need to make use of in order to interact with the controls, and the controls’ response to them. For example, to interact with an access control, the MAD would need to use their motor skills to approach and activate the control, and the control would need to provide the dog with a way of physically interacting and activating it. The model adapted below (Figure 29), describes the specific actions carried out by the MADs and the controls’ response as deemed necessary for a successful interaction.

![Figure 29: Adapted model of user-product interaction to MADs’ interactions with an access control](image)

6.2.2.3 Step 3 – Defining Usability Test Types

To evaluate the usability of a design throughout its development, interaction designers use a range of tests aimed at evaluating different aspects of the design. The choice of test is mostly based on the stage of the process the design is at. In our case, due to the similarities between the SIAC and the canine friendly prototypes, a comparative
verification test was chosen. This type of test can be applied throughout the design process and is aimed at comparing two or more different designs, prototypes, or finished products in order to determine which one provides the users with better usability and to understand the advantages and disadvantages of each design (Rubin and Chisnell, 2008).

6.2.2.4 Step 4 – Training

In order to ensure the study’s results would relate to the user’s behaviours associated with the use of the controls, as opposed to those associated with learning how to use them, this step aimed to ensure that the dogs were familiar with, and, fluent in operating the prototypes. To this end, a month prior to the study one blue and one yellow canine-friendly access control prototypes were installed at DFG. The yellow prototype access control (YPAC) was installed in the entrance hall of the DFG training building and used to operate a motorized door leading to an accessible toilet (Figure 30); and the blue prototype access control (BPAC) was installed inside the main training room underneath a SIAC whose function was disabled, and was used to operate the main training room door.

Figure 30: Installation of the YPAC at DFG headquarters

6.2.2.5 Step 5 – Identifying the Relevant Interaction Design Principles

As previously described in §2.2.4.1, ID principles are the most fundamental set of considerations used by interaction designers to determine if the design produced will meet the users’ requirements and afford them a good UX. Otherwise, “usability and
user experience goals simply cannot be achieved” (Mancini et al., 2016). Hence, assessing the extent to which design principles are implemented in relation to the animal users’ capabilities is critical.

In the case of this study, the relevant ID principles were identified based on MADs’ capabilities identified in step 2 of the MEAU and included the principles of **perceivability, consistency, feedback, and affordance.** Given the simplicity of the interaction under evaluation, I did not deem the principles of mapping and constraints relevant: the former because the representation of the controls’ input mechanism had no similarities with the output; and the latter because the controls allowed for only one input modality which was expected to be available at all times. This choice was supported by the work of Mancini et al. (2016).

6.2.2.6 Step 6 – Reframing Interaction Design Principles Based on the Users’ Capabilities

In order to make the design’s adherence to the relevant ID principles easier to assess, step six focused on reformulating them based on the animal users’ specific capabilities and on the interaction under evaluation. Doing so led to a more detailed understanding of how the principles had been implemented in relation to MADs’ interaction with an access control. The principles were reframed in the following manner:

**Perceivability**

Dogs need to be able to perceive the device in space, approach it and, if needed, identify and activate its operational parts (i.e. push-pad), using the intended mode of interaction (i.e. snout); and perceive any feedback emitted by the device (i.e. clicking sound when the push-pad is pressed). Hence, in order for MADs to perceive access controls, their design must adhere to the visual, auditory, and touch-based user requirements described in §4.3.1. For example, they should feature colours in the yellow-blue spectrum, be made of materials that are recognisable for the dog and may include features such as distinct textures and materials and be within the 200-4,000Hz acoustic range.
Consistency
Dogs are expected to be able to perform their naturally occurring behaviours (i.e. sniffing and mouthing), alongside any specific trained behaviours (i.e. nudge), to which the device needs to react in a consistent manner (i.e. open a motorized door every time the pad is pressed). Hence, in order for the controls’ design to remain consistent, it should be able to be successfully activated by the dog while using their snout in a natural manner. Additionally, the design must remain consistent in its functionality requiring the same amount of pressure and targeting of its push-pad to open the door while providing consistent feedback related to its activation.

Feedback
Dogs need to understand the feedback provided by the device (i.e. clicking sound), particularly if there is a time lag between when the device is activated (i.e. pressing a push-pad) and the resulting action occurs (i.e. door opens). In the case of MADs’ interactions with access controls, feedback is given by the controls’ push-pads movement, the clicking sound emitted as a result of the internal compression springs of the control, and by the trainers who are looking to mark the dogs’ behaviour and deliver a reward. Hence, in order for the MADs to receive accurate feedback from the control, the push-pads’ movement should be noticeable to the dogs, the click emitted by the control should be a result of the controls’ successful activation and consistently heard by the dogs, and the trainers mark of the behaviours should be delivered in a timely manner.

Affordance
Dogs need to be able to recognise the device’s operational parts (i.e. push-pad); hence, the controls’ push-pad design should provide features that allow MADs to recognise it as the control’s operational part, meaning the one they need to interact with in order to activate the control.

6.2.2.7 Step 7 – Assessing the Design Against the Relevant Principles
Due to the fundamental nature of the ID principles and the fact that if a product fails to adhere to those deemed relevant, it will not support its intended use and result in a
poor UX, and because in this case I was comparing a finished product (SIAC) and a set of high fidelity prototypes, the 7th step in the study consisted of a heuristic evaluation of the design’s adherence to the relevant principles. The evaluation involved the use of a simple evaluation matrix in which the devices’ features were plotted on its vertical axis and the relevant principles on its horizontal axis. When reviewing the intersections of the rows and columns, a simple rating scale between 1 and 3 where 1 indicated a low level of compliance, 2 indicated a moderate level of compliance, and 3 indicated a high level of compliance, was applied. The results of the heuristic evaluation of the access control’s adherence to the principles of perceivability, consistency, feedback and affordance are presented in §6.2.5.1.

6.2.2.8 Step 8 – Assessing the Design Against the Relevant Usability Goals

As discussed in §2.2.4.2, usability goals help designers assess specific aspects of an interactive product, thus determining the extent to which they provide good usability (Preece, 2015). When evaluating usability, prioritizing usability goals is important, as not all goals are equally relevant to all interactive products. Hence, considering the goal of the interaction under evaluation is key, which in the case of this study, consisted in the opening of a motorized door through the activation of an access control; making the goals of effectiveness, efficiency, and safety relevant to enable MADs to operate the control. While the goals of learnability, memorability and utility were not deemed relevant, given the fact that the MADs had been previously trained to operate the controls, the short duration of the study, and the simple nature of the device whose only input - the push-pad - was the only mode of interaction.

6.2.2.9 Step 9 Reframing the Relevant Usability Goals Based on the Interaction

Step 9 in the study focused on reframing the relevant usability goals based on the interaction under evaluation, which in our case were those of effectiveness, efficiency, and safety. Hence, evaluating the controls’ adherence to the goal of effectiveness aimed to measure the degree to which the controls enabled MADs to activate them; efficiency aimed to measure the quickness with which MADs were able to activate the controls; and the goal of safety considered the potential errors MADs could incur in while
interacting with the controls, and if the controls’ design enabled MADs to interact with them without performing unsafe behaviours.

6.2.2.10 Step 10 – Formulating Metrics for the Empirical Measure of Usability Goals

Step 10 is informed by common approaches used in ID, and similar approaches used in past ACI research to empirically evaluate the extent to which a design meets the relevant usability goals. When working with human users, designers often define usability benchmarks with which to evaluate their design, including for example, describing what a successful interaction entails and predetermining the time and number of steps it should take the user to complete tasks or goals (Rubin and Chisnell, 2008). Once these have been established, then usability metrics with which to measure the interaction can be defined. Furthermore, when working with human participants, researchers can seek verbal confirmation from the participant that they have understood the intent of the experiment. However, because of animals’ non-verbal nature, this is not possible; hence, most human-centric approaches need to be adapted. For example, past ACI research developed metrics which helped the researchers contextualize the animals’ behaviour to specific aspects of a design, enabling them to use the results of the empirical studies to inform changes to the design. For example, the work of Zeagler et.al (2014) whose empirical study of MADs interacting with a touchscreen led to the definition of design parameters for the design of touchscreens for canine users (§2.4.4).

However, not all usability metrics can be tied back to a specific feature of the design; because, as described above, we cannot ask animals what the intent behind their behaviour was. In the case of this research, the metrics developed aimed to be as specific as possible regarding the results of the behaviour measured and its direct consequence on our understanding of the controls usability, and any resulting changes to its features that might improve it.

Effectiveness

One way of determining the degree of effectiveness in interacting with a device is measuring the appropriateness of the systems responses to the users’ actions, as they relate to the intended outcome of the interaction. In this case, the intended outcome is for the door to be opened by the MAD on behalf of the human. For this to have the
highest probability of occurring, the controls should activate when the dogs come into contact with them; hence, the more sensitive the control is in responding to the MADs’ contact with it, the more effective the interaction will be. Therefore, in order to assess the controls’ compliance with the goal of effectiveness, the following metric was formulated:

\[
CE = \frac{\text{NCC}}{\text{DO}}
\]

\[
\text{NCC} = \text{number of contacts made with the control}
\]

\[
\text{DO} = \text{number of times the door opened}
\]

**Efficiency**

*Efficiency* relates to the amount of time and energy the user expends when completing a task. When working with humans, efficiency is a straightforward measurement, as you can easily communicate to participants the importance of the speed at which they carry out the task and obtain confirmation of their understanding. However, when working with animals we cannot assume that they have understood the importance of time for the assessment of the interaction. Arguably, in the case of this research, we could assume that in having been trained to carry out a command at the end of which they have learned to expect a reward, MADs would want to receive the reward as soon as possible, and in fact this might mostly be the case. However, it also might not, with their delay in executing the command being a result of, for example, them knowing that they will receive the reward soon enough, so why not, while approaching the control, turn their attention to a noise or smell they might have perceived. Hence, in order to gain a better understanding of how efficient the control is, I thought it prudent to compliment the measure of the time it took MADs to carry out the command with a measure of how many attempts they executed before actually activating the controls. Here again, we face a similar issue as the one described above where we cannot confirm that the MADs have understood that they must activate the control while exerting the least amount of energy; which in the case of this research, I have assumed to be the easily observable parameter of the number of attempts executed by the dogs while trying to activate the control. Yet by considering the results of these two measurements together, we might be able to better assess the MADs’ experience while interacting with the control, and
its degree of efficiency in enabling the MAD to open the door; whereby a control that 
takes the MAD a longer time to open and results in a higher number of attempts to do 
so would arguably be less efficient. Therefore, in order to measure the controls’ degree 
of efficiency the following metrics were formulated:

Average Time to Open (ATO) = TDO-TFCI/DO
TDO: time door opened
TFCI: time first command prompt was issued by the trainer
DO: number of times the door opened

Average Energy to Open (AEO) = NA/DO
NA: number of attempts to contact control
DO: number of times the door opened

Safety as it Relates to Error
Safety as it relates to error rate is usually calculated by counting the number of errors a 
user might make when completing a task. This enables designers to investigate if the 
error occurs because a design is not providing the user with the appropriate 
functionality or the user might not have understood how to engage with it. In the case 
of this research, there are many types of errors that could be quantified; including for 
example the number of prompts issued by the trainers compared to the number of times 
the dogs’ activation of the control caused the door to open. However, although 
informative in nature; the focus here is on developing a design and not on measuring 
MADs’ comprehension of executing a command. Hence, the type of error that would 
be of interest is one that would help reveal a feature of the design, which due to its 
shape or function, might be causing the dogs to not be as successful in activating the 
control. The metric used to measure the goal of effectiveness could arguably also be 
used as an indicator of error; however due to the construction of the controls (spring 
loaded push plates) a successful activation might also be a result of the dogs’ ability to 
target the center of the push-pad. Alternatively, the dogs’ ability to target the controls’ 
push-pad as opposed to other parts of the control could also be valuable to investigate. 
If we were to measure the former we would not still not be able to establish if the issue 
with the control was a function of its internal mechanism as such, or the fact that the 
square shape of the control would most likely be less sensitive towards it’s edges and 
more sensitive towards its center. If we were to measure the latter, then we would be
able to quantify the dogs’ targeting of the controls’ push-pad; and thus, inform our understanding of the degree to which the dogs were coming into contact with the controls operational parts, or in other words, committing the error of coming into contact with its non-operational parts. Hence, in order to measure the goal of safety as it relates to error rate the following metric was formulated:

\[ \text{Error rate (ER)} = \frac{\text{NPC}}{\text{NCC}} \times 100 \]

\[ \text{NPC} = \text{number of contacts with the controls’ push-pad} \]
\[ \text{NCC} = \text{number of contacts with the control} \]

**Safety as it Relates to Design**

Informed by our understanding of the risk that jumping might have to MADs’ health (§4.3.1), when assessing the controls’ safety as it relates to its design, I focused on quantifying the number of times MADs jumped in order to activate the controls. Additionally, measuring this behaviour would also inform my understanding of the appropriate installation height for the controls, another variable which we were investigating during this study (§6.2.3). Hence, the metric formulated was:

\[ \text{Jump Rate (JR)} = 100 \times \frac{\text{NJ}}{\text{NA}^*100} \]
\[ \text{NJ} = \text{number of jumps} \]
\[ \text{NA: number of attempts to contact control} \]

### 6.2.2.11 Step 11 Empiric Assessment of the Design Against the Relevant Usability Goals

Step 11 is described in detail in the following section relating to the study’s second stage of data collection regarding MADs interactions with the controls. Additionally, it is important to note that depending on the interaction under evaluation this step will require different types of data collection; however one aspect that should always be considered is the means used to observe and record the animals’ behaviours, which due to their fast occurring and nuanced nature will need to be clearly visible to the researchers.

### 6.2.3 Data Collection

Data collection for the study was carried out in two stages. The first was an online survey given to the trainers two weeks prior to the study for them to record their hypothesis
regarding how the different designs of the controls would perform during their training and use. The second stage took place at DFG headquarters on January 23rd, 2019 and consisted in the observation and video recording of nine MADs as they interacted with a SIAC, BPAC and YPAC (Figure 31). The SIAC had an approximate size of 132mm x 127mm x 1143mm and consisted of a smooth black plastic enclosure with a flush spring-loaded metal push plate. The BPAC and the YPAC consisted of a plastic enclosure with a lightly texturized and slightly protruding spring-loaded push plate of the same colour and material. The prototypes had an adjustable height feature, enabled through the use of Velcro fasteners which adhered to the training room’s walls. They had a size similar to that of SIAC, and the same wireless pairing feature that allowed them to open the motorized door. The most notable differences between the existing SIAC and the prototypes were: i. their material (metal vs plastic); ii. their colour (metallic grey vs bright blue and yellow; iii. their push plate’s surface finish (smooth vs lightly textured); iv. the amount of pressure needed to activate the control (firm vs soft); v. the protrusion of their push plate (flush vs an approximate protrusion of 5mm); vi. the clicking noise produced by the control when pushed (just audible to loud); and vii. the installation of the controls (fixed vs adjustable).

![Figure 31: SIAC, BPAC and YPAC controls](image)

Due to its compliance with accessibility standards (2016) and being the height commonly suggested by manufacturers for access control installation, the first observations consisted in comparing the use of the three controls when installed at a height of 750mm off the ground. Because a “nudge” command requires the dog to use their snout, the second height tested - labeled as ‘snout’ height - was determined using MAD participant’s individual measure of the distance between their snout as they
looked forward and the ground. The third height tested was aimed at assessing the viability of a potential plug-in version of the design and was therefore based on the distance between the ground and the center of a standard electrical socket, or 450mm. To control for environmental variables that might have affected the participants, the study took place inside the charity’s main training room, where the room’s main access point was outfitted with a motorized door.

Data collection was carried out during three sessions, one for each control height tested. In order to prevent trial fatigue on the part of the dogs and their trainers, each session involved a trainer and one of their three dogs executing a “nudge” command from three to six times. Once the first participants had finished their trails, they were replaced by the following pair and so on. Each dog carried out an average of 33 trials with 9 trials carried out while interacting with the SIAC at 750mm height, 6 trials with the BPAC and YPAC at 750mm height, and 3 trials with the BPAC and the YPAC at ‘snout’ and 450mm height. In total 289 trials were recorded out of which 3 were excluded from the data set due to lack of clear footage (Table 4).

<table>
<thead>
<tr>
<th></th>
<th>SIAC at 750mm</th>
<th>BPAC at 750mm</th>
<th>YPAC at 750mm</th>
<th>BPPAC at snout</th>
<th>YPAC at snout</th>
<th>BPAC at 450mm</th>
<th>YPAC at 450mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>D2</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>D3</td>
<td>9</td>
<td>6</td>
<td>5^</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>D4</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>D5</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>3</td>
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<td>3</td>
</tr>
<tr>
<td>D6</td>
<td>8^</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>D7</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>3</td>
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<td>3</td>
<td>3</td>
</tr>
<tr>
<td>D8</td>
<td>9</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>D9</td>
<td>8^</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>3</td>
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<td></td>
<td>79</td>
<td>54</td>
<td>53</td>
<td>27</td>
<td>27</td>
<td>22</td>
<td>27</td>
</tr>
</tbody>
</table>

^Trial excluded due to lack of clear footage of the dog’s interaction with the control

Table 4: Data set of study trials

Each trial started with the trainer sitting in a motorized wheelchair and gaining the dog’s attention. As they slowly moved towards the access control – at an approximate distance of 2m - 1.5m from the control - the trainer would issue the “nudge” command. If the dog was not successful after the first issue of the command, the trainer would either repeat the command or offer other verbal (e.g. “good lad”) and non-verbal (pointing, looking at the control) cues. If the dog had made several unsuccessful attempts, the
trainer would reposition the powerchair to better direct the dog towards the control. Then, once the dog had successfully activated the control using their snout, the trainer would mark the behaviour with a verbal cue (e.g. “yes”) and offer the dog a food reward. As the door opened the trainers would slowly move away from the door and reposition themselves and the dogs for the next trial while waiting for the door to come to a complete close.

In order to better understand the position of the dog’s body in space during the trials, the area adjacent to where the access controls were installed was set-up in a similar fashion as to what is commonly used in human-centric ergonomic testing (Rubin and Chisnell, 2008), whereby a 1000mm grid overlay was glued to the wall and floor using a thin 4mm black tape. To obtain improved video footage of each trial, three separate cameras were set up to capture multiple angles (posterior, overhead and side) of the interaction. The overhead angle was captured using a GoPro Hero 4 camera mounted atop a boom pole (a fixture commonly used for scene lighting); the posterior view was captured using a GoPro Hero 1 camera mounted on a small tripod set on a chair, and the side view was captured using an iPhone 7 mounted on a small tripod attached to a table (Figure 32).

![Figure 32: Ergonomic grid and camera set-up for study data collection](image)

### 6.2.4 Data Analysis

Responses from the trainer surveys were tabulated and, in order to compare their attitudes towards the controls after the end of the study, each trainer’s input was shared and discussed with them individually. The content of these discussions was compared to the trainer’s original hypothesis as a means to validate their assumptions and attitudes towards the training and use of the controls. Video footage of the trials was...
reviewed using the ObjectusVideo V.1.0.2 software which allowed for a frame by frame playback. The data was systematically recoded in a Microsoft Excel spreadsheet using the following categories: participant identifier (D1-D9), camera used to record the video (posterior, overhead or side), control being tested (SIAC, BPAC, YPAC), control installation height (750mm, snout, 450mm), trial number (1-9), time stamp of when the “nudge” command was verbally issued by the trainer, time stamp of when the dog had come into contact with the control, the mode of interaction used (snout, right paw, left paw, other), part of the control the dog came into contact with, and number of attempts in activating the control during each trial.

6.2.5 Findings

The following sections present the study’s findings in detail.

6.2.5.1 Heuristic Assessment of the Design Against the relevant ID principles

The heuristic evaluation of the control’s adherence to the interaction design principles were calculated as percentages (Table 5). All of the controls received scores higher than 50% which deemed them usable by the dogs. Since the prototypes (BPAC and YPAC) had been specifically designed to comply with the interaction design principles of perceivability, feedback, and affordance, we expected them to score better than the SIAC, a hypothesis which was confirmed. The relevance of these scores to usability goals was subsequently determined through the empirical evaluation of the controls’ design against them.

<table>
<thead>
<tr>
<th>SIAC</th>
<th>Perceivability</th>
<th>Consistency</th>
<th>Feedback</th>
<th>Affordance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max. score 24*</td>
<td>Max. score 15</td>
<td>Max. score 12</td>
<td>Max. score 6</td>
</tr>
<tr>
<td>13.2x12.7x11.43cm</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Smooth black plastic enclosure</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flush push plate</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Not height adjustable</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Metal push plate</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Moderate pressure to activate</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Spring loaded push plate</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Audible “click” when pressed</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Totals</td>
<td>58.33%</td>
<td>66.67%</td>
<td>66.67%</td>
<td>66.67%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BPAC &amp; YPAC</th>
<th>Perceivability</th>
<th>Consistency</th>
<th>Feedback</th>
<th>Affordance</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.2x12.7x11.43cm</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Slightly textured blue plastic enclosure</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5cm push plate protrusion</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
6.2.5.2 Assessment of the Design Against the Relevant Usability Goals

The following sections summarize the results relating to the controls’ adherence to the relevant usability goals when installed at 750mm, ‘snout’, and 450mm height.

Effectiveness

With regard to effectiveness (Figure 3), the results show the YPAC at 450mm height required MADs to make the least number of contacts with the control (1.10) in order to activate, followed by the BPAC (1.30), and the YPAC at ‘snout’ height (1.44); and the BPAC at 450mm height (1.48). The SIAC at 750mm was by far the worst performer, requiring MADs an average of (8.82) contacts to activate. The BPAC (3.00) and YPAC (2.05) at 750mm although scoring significantly lower than the SIAC, required more contacts to activate than when installed at the lower heights. These results seem to confirm the influence of the controls’ level of sensitivity on its effectiveness, evidencing that the more sensitive BPAC and YPAC required less contacts to activate. However; difference in the results of the prototypes when installed at 750mm height, and the lower ‘snout’ and 450mm height also evidence the importance of an accessible installation height; because, even though they were more sensitive to MADs contact, the fact that they weren’t as reachable made them less effective. This is further supported by results such as those of MAD1, MAD5 and MAD9. In the case of MAD 1 her interaction with the SIAC (1.56), was comparable to those of the prototypes, partly explained by her height, which due to being a Golden Retriever cross with a German Shepard made her taller than the rest of the participants allowing her to activate the controls installed at 750mm with a higher degree of ease. This in contrast to MAD5’s results (16.25) who although similar in height to MAD1, had a very gentle “nudge” confirming that even though the SIAC was reachable, its lower sensitivity impacted its effectiveness. In regard to MAD9, who averaged (2.0) attempts when interacting with

<table>
<thead>
<tr>
<th>Height adjustable</th>
<th>3</th>
<th>3</th>
<th>-</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slightly textured blue plastic push plate</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Low pressure to activate</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Spring loaded push plate</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Loud “click” when pressed</td>
<td>3</td>
<td>-</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Totals</td>
<td>91.67%</td>
<td>93.33%</td>
<td>91.67%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 5: Heuristic evaluation of the controls’ adherence to the relevant interaction design principles
the SIAC, his result is partially explained by him being a highly energetic dog that seemed to be very accurate in his targeting of the SIAC’s push-pad (confirmed by his results in regard to error rate presented below). Furthermore, MAD3’s apparent struggle to interact with the BPPAC at 750 height is important to address, a result which when further analysed seems to be due to him being highly distracted during the session and not a result of his ability to carry out the command.

![Control Effectiveness (CE): average number of contacts per trial needed to activate the control](image)

**Efficiency**

In terms of the goal of efficiency (Figures 34 and 35), the most efficient control in terms of speed, taking MADs’ an average of (1.88s) to activate was the BPAC at ‘snout’ height, closely followed by the BPAC at 750mm height (1.9s). The worst performers were the BPAC (3.38s) and YPAC (4.18s) at 450mm height. This result, when compared to the controls’ level of effectiveness could be counterintuitive; because a more accessible height (450mm) should in theory be quicker to reach and thus quicker to activate.
However, when compared to the results of the number of attempts needed to activate the controls when installed at 450mm, the prototypes scored slightly higher, with the BPAC and YPAC at snout height requiring (2.5) and (1.9) attempts respectively. This could be a result of the prototypes’ lower height being unfamiliar to the dogs, compared to the devices they commonly interact with which are usually installed at heights that respond to human accessibility and are therefore higher. Alternatively, it could also be that encountering a device at such a low height required some of the MADs to adopt a posture which they might not associate to executing a “nudge” command.

Additionally, the most efficient controls in terms of the number of attempts needed to activate them were the BPAC and YPAC when installed at ‘snout’ height. When considered holistically, and regardless of whatever the exact reason behind the MADs behaviour might be, the results seem to evidence an ideal height range for device installation when executing a “nudge” command. Furthermore, these results continue to evidence the impact of MADs3’s level of distraction when interacting with the BPAC at 750mm (17s), making him a clear outlier both when compared to his other interactions with the controls and among the other participants.

![Control efficiency (ATO): the average time in seconds needed to activate the control](image)
Safety

With regard to the goal of safety, as related to the controls’ error rate (Figure 36), it was the YPAC at 450mm height that obtained the highest score, meaning that the MADs’ targeted the control but not its push-pad 65.7% of the time; conversely, when
interacting with the BPAC when installed at 750mm height this mistargeting only occurred 23.4% of the time. Here it is important to note the influence of MAD9’s performance when interacting with the controls; where his highly targeted jumps made him mistarget his interactions with the SIAC only 6.3% of the time, while when interacting with the BPAC at 750mm height, he had a 0% error rate. These results seem to support the hypothesis that a dog who is performing a behaviour well, when given the opportunity to do so under improved circumstances, in this case provided by the BPAC’s increased sensitivity, will improve their overall performance. Furthermore, the results show a lower error rate when interacting with the prototypes when installed at 450mm height; confirming that an accessible height is easier for the dogs to target. However; when considering the results of the BPAC (39.3%) and YPAC (65.7%) when installed at a 450mm height, the existence of an appropriate installation height seems to be confirmed.

![Figure 36: Results of the controls’ adherence to the goal of safety as error rate (ER)](image-url)
On the one hand it could have been hypothesized that the dogs should have had a lower error rate when targeting the SIAC whose design had a difference in colour and material between the control’s casing and its push-pad; hence providing a the dogs with a perceivable difference between its operational and non-operational parts; however, this was not the case. This result could be explained, as previously mentioned, due to the control’s height and lowered degree of sensitivity; however; it could also be a result of other factors such as its push-pad being metallic; a material which is has been reported as being commonly disliked by dogs. However; because the goals of effectiveness and efficiency have also been measured; even though the control’s materials are a factor to consider, the controls’ height and degree of sensitivity seem to be the predominant factors that most influence MADs performance. Additionally, it is important to note that the higher error rate of the YPAC at ‘snout’ and 450mm height might have been a result of the dogs not being able to target the push-pad due to frustration and not ability; as it was during the trials with these controls that the dogs’ had the highest number of activations while using their paws (14 instances).

In regard to the goal of safety related to the number of jumps executed by MADs when interacting with the controls (Figure 37), the worst performer was the SIAC, requiring MADs to jump 44% of the time; followed by the BPAC (38%), and YPAC (27%). These results are not surprising as it would make sense that when installed at a height which was less accessible to the dogs they would be required to jump in order to activate them, in contrast with the results of the jump rate for the prototypes when installed at ‘snout’ (BPAC 8% and YPAC 9%) and 450mm (BPAC 0% and YPAC 10%) height; however, they remain significant measures of just how much the installation height of the controls influences the dogs UX. Additionally it evidences that even though the dogs required a higher number of jumps to activate the prototypes when installed at 750mm height (BPAC 38% and YPAC 27%), the controls’ increased sensitivity also seemed to reduce the number of jumps needed to activate them.
6.2.5.4 Results of Trainers’ Hypothesis Prior To and After the Study

Trainers were asked to hypothesize how the prototypes would perform compared to the SIAC while training the dogs to use the prototypes and after they had reached fluency in executing a “nudge” command in relation to the MADs’ locating, approaching, and activating the controls. They were also asked to consider if the prototypes would in any way influence their training approach. The trainers answers to these questions were discussed with them once the data collection was complete and, based on their actual use of the controls, they were again asked to re-consider their answers.

In regard to their hypothesis regarding the training of the controls, two of the three trainers thought the prototypes would be easier for the dogs to locate and activate with one of them commenting, “the prototypes may provide more of a natural intrigue on the part of the dog which can be used to aid training.” When asked about their answers
after having trained the MADs to use the prototypes, the trainers updated their responses to evaluate the prototypes as being easier to locate and activate while keeping their response to the ease of training the approach the same.

With respect to the trainers’ hypothesis regarding the actual use of the controls, one trainer thought the prototypes would be easier to locate; commenting “they might provide more contrast”, while the other two thought there would be no impact. In regard to approaching the controls, two trainers thought they would be easier to approach and one thought there would be no impact commenting “they learn to nudge a target first, so they should learn to nudge these the same”. Two trainers thought they would be easier to activate with one of them commenting “the lower height may help an underconfident dog who is unsure of jumping.” After having used the controls, the trainers updated their evaluation of the prototypes to two of the trainers considering them easier to locate, and all trainers agreeing the prototypes had been easier to activate than the SIAC.

With regard to the changes in the trainers’ behaviours, two out of the three trainers thought the prototypes would influence the way they train with one of them commenting “they are more visually obvious, so this might make it easier”. They also thought the prototypes would change the amount of support they gave the dogs with one of them commenting “potentially, as if they find it easier to learn then they wouldn’t need as much support.” All trainers agreed that they BPAC and YPAC would not influence the way they reward, with one trainer commenting “no task affects the way I reinforce, only the successful completion of the behaviour.”

When asked to hypothesize what the most notable difference would be when training and using the prototypes as compared to the SIAC, one of the trainers commented “I think the biggest difference will be capturing the intrigue that the brighter colours provide more readily,”, while another added thinking that the controls’ height would impact the interaction commenting, “colour and height may provide a more enjoyable learning experience, as occasionally the height of our current controls causes some frustration.”
6.2.6 Discussion

Although the evaluation approach applied in this study was complex and time-consuming, it enabled me to systematically and comprehensively analyse MADs interaction with access controls, supporting a detailed assessment of the interface’s usability. Examining the characteristics of the system in question, the intended user, and the task that needed to be completed for a successful interaction, allowed the identification of relevant interaction design principles and usability goals against which to evaluate the design of different controls. Of course, as previously mentioned, measuring usability does not mean understanding the experience of other animals; however, it enabled the identification and measure of important factors that served to inform their user requirements. The following sections discuss these in more detail.

6.2.6.1 Assessing the Design Against Relevant Interaction Design Principles

The MEAU in its current state proposes a heuristic assessment of a design’s adherence to the relevant, reframed, interaction design principles. As evidenced in the findings, doing so brings up three interesting aspects of evaluating animals’ usability. The first relates to the value in defining the relevant principles and reframing them based on the animal users’ characteristics; which would seem to promote the contextualization of the users’ specific characteristics towards the evaluation and indeed the development of the design. The second aspect is the evaluation itself, which in our case might seem like a superfluous step due to the MADs having already proven to be able to interact with the controls. However, in cases where the design is completely novel for the animal or the interaction more complex, including this step as part of the design’s usability evaluation, and quite possibly during the initial stages of development, will help to ensure that the result is in fact usable by the animal. Lastly, due to the fundamental nature of the principles and their direct relationship to a users’ characteristics and capabilities, a heuristic evaluation seems to be sufficient. However, it is equally important to support these findings with empirical evaluations, which in our case focused on usability goals. For example, the BPAC and YPAC received a score of 100 when evaluating the degree of affordance, they would provide the MADs. One way to validate this score empirically was by evaluating the designs’ adherence to the usability goal of safety, specifically its error rate (ER) which considered the total times the MADs
came into contact with the controls’ push-pad as opposed to other non-operational parts such as its edges or the wall it was affixed to. If we were to calculate the average ER of the prototypes when installed at all heights, the result would be a combined ER of 34.66%, which would not support an affordance score of 100% even if we were to use other additional metrics to address other aspects related to the principle. Hence, although a heuristic evaluation is sufficient to orient the researcher in terms of the design’s ability to be used by the animal user, it alone does not provide a detailed understanding of the interaction, needing to be supported by empirical evaluations as well.

### 6.2.6.2 Assessing the Design Against Relevant Usability goals

Overall, the evaluation of the control’s adherence to the usability goals produced results which confirmed our initial hypothesis that the canine-friendly design of the prototypes would outperform the SIAC. This was in fact the case when the BPAC and YPAC were installed at 750mm height, and by a more significant margin when installed at ‘snout’ height. However, it was interesting to note that despite their features responding to the MADS’ characteristics as users, when installed at 450mm height, they performed worse that the SIAC. These results evidence the impact and importance of the devices’ accessibility, specifically their installation height on the MADS’ UX. Overall, the control that afforded MADS’ the best usability was the BPAC when installed at ‘snout’ height, providing more evidence to confirm the importance of an accessible installation height, while possibly revealing that a colour which arguably has a higher contrast within its surrounding environment (blue on white background) affords MADS a better usability than the YPAC’s lower contrasting colour (yellow on white background).

Additionally, it is when considering the individual and compounded scores of the controls’ adherence to the goals that one can begin to extract important insights of information that inform the existing MAD user requirements. For example, consider the situation described above regarding the goal of safety as it relates to error rate. These results imply that even though the prototypes’ colour and sensitivity were adjusted to better respond to MADS characteristics as users, the dogs were still not consistently targeting the controls’ push-pad. This opens up the discussion as to why this might be the case. Is it because the prototypes’ push-pad and casing are the same colour and
are not providing a clear enough distinction for the dogs of which part of the control to nudge? Could the controls’ square shape be harder to clearly perceive by the dogs when at a close distance and thus causing them to use their snouts to investigate and come into contact with their edges or the wall? Or could it be the texture of the prototypes which although offering MADs with a better experience compared to the metal finish of the SIAC might be causing them to at times avoid it? Here again we are confronted with the complexities of ACI research and working with animal users because, if the users of the controls had been human, they could have been asked to explain the intentions behind their actions. However, because this is not the case, the role of usability metrics in the evaluation of animals’ UX should probably be articulated in a way in which the limitations of establishing true meaning based on their results is clearly expressed. For example, in this case of the proposed metric for measuring effectiveness, the results from the study were easily correlated to the controls’ degree of sensitivity; thus, leading to the articulation of a precise MAD requirement regarding the level of sensitivity needed by MADs. However, when considering the ER metric described above, the relationship between MADs’ quantified behaviour and a specific user requirement, or for that matter a feature of the design remained unclear; due mostly to the number of factors which could have influenced their behaviours. Hence, it is critical to establish the different levels of fidelity of the usability metrics formulated to evaluate the designs’ adherence to the usability goals, as some will inform our understanding of the animals’ UX more precisely (e.g. informing the design of a specific feature), while others will provide more general guidance (e.g. increasing our awareness about a design feature and promoting further investigation).

6.2.6.3 The First Iteration of the MEAU and the Role of Individualized Measures

The evaluation approach taken in this study places emphasis on species-specific characteristics rather than on individual particularities. This might seem contrary to the results of the previous study (§6.1), in which the importance of accounting for variations in the users’ individual traits and their implications for the meaning of the behaviour they exhibit during an interaction was evident. However, in order to eliminate a variable that would undoubtedly increase the time and resources needed to accurately analyse the data, and due to the novelty of the MEAU, and the experimental nature of some of
its approaches, I thought it best to investigate usability at a species level first. This is partly due to the fact that ACI is still a relatively new field, whose methods and approaches are still being developed. Therefore, it seems sensible to focus on incrementally investigating the UX of animals’ interactions with technological devices, rather than trying to account for animals’ individual characteristics all at once. Arguably, an understanding of the systemic nature of an individual animals’ UX, and how the different aspects and elements relate, influence, and support each other is necessary before, as ACI researchers, we can begin to measure the UX. However, what seems particularly important at this stage is to measure and analyse the relationships between the elements that make up the animal UX and how they might influence each other and apply the understanding of these established relationships when investigating the individual user.

6.2.6.4 Trainers’ Hypothesis

The results of the trainer’s hypothesis seemed to confirm the findings, with most trainer responses accurately predicting the way the controls would perform during the study. However, once interacting with the controls, some trainers updated their responses to reflect their empirical experience of use with the controls. This raises the question of when and how best to integrate expert knowledge into the evaluation of the animal UX. On the one hand, in this study, you have a pre and post evaluation of the controls’ usability by the trainers which although informed by their empiric use of the controls is based on their overall sense of how the dogs performed and not on the quantified measure of the MADs’ behaviours. On the other hand, past ACI research such as that of Mancini et al. (2012) and Resner (2001), relied upon the dog’s handlers to inform their evaluation of their UX. For future studies it would be interesting to investigate how to systematically leverage expert feedback in order to better understand the MAD UX.

6.2.7 Study Limitations

This study demonstrates a first application of a method for evaluating animal usability (MEAU). The results from this evaluation are subject to the method’s current state of development, which - based on the results presented in the findings and discussed above - is in need of further work to improve its efficacy. For starters, the MEAU was
applied to the evaluation of nine MADs’ interactions, which although a higher sample size than that of the previous study (3 MADs) remains low. Additionally, as discussed in §6.2.6.3 the focus on the species-specific measurement of usability limits the understanding of the individual nature of the MAD UX. Furthermore, more detailed aspects of the dogs’ interactions with the controls where not recorded, some of which might have produced the formulation of higher fidelity metrics which would have allowed a better understanding of the controls’ usability. For example, by measuring the frequency of the sounds emitted by the controls and analyzing if there was a difference between the sound emitted by the spring when partially or fully compressed, would have given us a better understanding of the role of the controls’ clicking sound as feedback for the dogs. Moreover, installing the BPAC and YPAC controls in the place of the SIAC within DFG’s main training room could have affected how the dogs’ interacted with them. On the one hand it provided them with a consistent set-up of where to look for when given the “nudge” command within this specific setting; yet it could also have impacted their level of performance as the dogs might have been carrying out similar movements to come into contact with a control irrespective of it being a SIAC, BPAC or YPAC.

6.2.8 MAD User Requirements

Based on the data presented in the previous studies, a set of emergent MAD user requirements are presented below. Some requirements evidence precise specifications while others, as discussed in §6.2.6.2, provide more general considerations.

- Due to the influence of the controls’ level of sensitivity on the MAD UX, MADs would benefit from devices whose degree of sensitivity allows them to use their snout to activate it. The degree of sensitivity should be in a similar range to that of the prototypes (BPAC and YPAC) previously developed by Mancini et al. (2016).

- Due to the importance of accurate feedback on the MAD UX, MADs would benefit from devices that either provide them with clear and timely feedback as to the result of their interaction with them; or provide their human handlers with clear and timely feedback as to the result of MADs’ interactions with them so as to be able to adequately mark the behaviour.
• Due to the varied **modes of interaction** MADs exhibit while interacting with devices, they would benefit from a design that is simple in nature and that provides them with information on how to interact with them with little to no need for human help or support.

• Due to MADs’ **visual capabilities** and their influence on MADs’ ability to locate the device in order to interact with it, MADs would benefit from devices whose colour contrast with the surrounding environment.

### 6.3 Chapter Summary

This chapter reported on two studies that addressed the second supporting research question, *(srQ2 “What methods might ACI practitioners use to inform the design and evaluation of canine-centric interfaces?”)*, by investigating MADs active interactions with tangible interfaces; specifically, on their use of access controls.

The first study focused on three MADs’ affect-based interactions, specifically on the observation of their tail wagging behaviours in relation to their personality as measured by the MCPQ-R. A tail wagging ethogram was developed, was a measurable behavioural parameter of individual behavioural characteristics to measure MADs’ state during their interactions with technical devices.

The second study investigated the usability of two types of controls, a SIAC and a set of early prototypes previously developed by Mancini et al. (2016). It proposed the MEAU, an 11-step method to evaluate animal usability. The MEAU allowed me to gain an understanding of the nuances of evaluating animal revealing that some metrics will produce results which can be more easily tied to a user requirement while others will remain general in nature. Additionally, trainer feedback was incorporated as pre and post study surveys in which their hypothesis relating to the usability of the controls being compared was recorded, with their responses remaining consistent, highlighting the importance of expert user feedback to the evaluation of the animal UX.
Phase 4: Designing for the MAD User
7. Evolution of a Design

This chapter continues to address the second supporting research question, (srQ2 - “What methods might ACI practitioners use to inform the design and evaluation of canine-centric interfaces?”), by presenting the evolution of the design of a series of smart control prototypes for MAD use. The following sections describe their development.

7.1 First Iteration: From ideation to Low Fidelity Prototype

The aim of this first iteration was to develop a series of initial design concepts for a set of smart controls for MAD use. As is common within an ID process, the first iteration of a design usually aims to produce concepts that are highly creative and that, informed by the users’ requirements, in this case MADs, push the boundaries of what might be possible (Preece, 2015). This was achieved using prototyping methods that are common in ID and ACI, such as hand sketching and low fidelity prototyping. The concepts were evaluated based on how well they met MADs’ user requirements. The following sections describe this process in detail.

7.1.1 Participants

Participants were 8 DFG staff including 3 full time trainers (FT1, FT2, and FT3), 3 part time trainers (PT1, PT2, and PT3), 2 instructors (I1 and I2) and Duncan Edwards, the client relations manager and research liaison.

7.1.2 Method

The development of the 1st iteration of concepts took place during the months of April and May 2019. In order to quickly generate a wide variety of designs, I used concept generation matrices (Kumar, 2012) to plot the MAD users’ requirements on the matrix’s vertical axis and the system requirements on the horizontal axis. In reviewing the intersections between the rows and columns, I was prompted to conceptualize different design alternatives, resulting in a series of hand-drawn sketches (Figure 38) depicting various design concepts in which specific features of their intended modes of interaction, type of feedback, installation, activation, and intended command were described.
7.1.2.1 Initial design concept generation

![Diagram of initial design concepts](image-url)
7.1.2.2. Heuristic Assessment of the Initial Concepts

In order to assess the viability of the initial 16 concepts, these were heuristically evaluated using a method similar to that presented in §6.2.5.1; with the difference being that here the concepts were evaluated based on how much their features responded to...
MADs’ user requirements as opposed to their adherence to ID principles. The results of this evaluation are presented in §7.1.3.1.

7.1.2.3 Concept Refinement

Based on the results of the concepts’ heuristic evaluation, the highest-rated concepts were further refined, and redrawn in more detail. Figure 39 shows thumbnails of the second series of hand drawn sketches (for full sized images Appendix 10).
7.1.2.4 Concept Evaluation Workshop

A concept evaluation workshop was held at DFG facilities on April 3rd, 2019. Concept evaluation workshops are carried out throughout the design process to provide designers with a means to quickly and systematically elicit user response and feedback to design concepts (Kumar, 2012). In this case, it was the trainers feedback relating to the concepts and based on their relevant expertise and insight into MAD behaviours. The concepts were mounted at eye level height on the wall of a DFG conference room, thus providing participants with a clear and non-hierarchical view of them. Once all participants arrived, I introduced the session’s activities and objectives and provided
them with brief descriptions of each concept. Participants were then given a set of adhesive coloured voting dots and instructed to use them to assess the concepts as follows: 1 red: most likely to improve MADs’ performance; 1 yellow: preferred concept to train with; 1 green: most overall potential in providing MADs a good UX; and 2 blue: top two overall choices. Participants were given 10 minutes to cast their votes by fixing the coloured dots directly below the sketches. Afterwards I facilitated a general discussion in which participants commented on their voting choices, discussed the best and worst rated concepts, and provided more specific feedback on their top-rated concepts.

The workshop’s discussions were transcribed into a Microsoft Excel file format and analysed using a deductive coding approach based on the comments made about the concepts, specifically their ease or difficulty of training, their general use, and any challenges they might cause the MADs when interacting with them.

7.1.2.5 Low Fidelity Prototypes

In order to conceptualize the top-rated concepts as three-dimensional artefacts, a set of low fidelity prototypes were constructed using basic prototyping materials and store-bought components (Figure 40). These were showcased during the 2019 annual Edinburgh Science Festival (Appendix 11), where they were shared with the general public and DFG staff, receiving positive feedback regarding their design and use. Some of the prototypes were informally tested by the dogs with footage of some of these interactions featured on the BBC Scotland nightly news.

7.1.3 Findings

The following sections present the results of the concept evaluations, alongside feedback related to the initial low-fidelity prototypes.

7.1.3.1 Concept Evaluation Matrix Results

The initial 16 concepts aimed to address MADs’ user requirements; however, some designs addressed some but not all requirements; while others addressed all of them. Hence, the evaluation of the concepts was based either on the ease with which the
requirement could be added to the design moving forward or on how well they appeared to meet the requirements (Appendix 12). Results revealed the 3 highest rated concepts to include **strip**, **push**, and **boink** which obtained a score of (34); **fresh light**, and **rip** with a score of (33); and **a remote, proxima, and treat box** with a score of (32). Concepts receiving the lowest scores were eliminated (**grab light** (30), **edible** (28), **sit mat** (31), and **up and down** (30)). Additionally, based on my interest in obtaining expert feedback on a few concepts whose scores although low seemed to have potential, the concepts of **weight** (30), **sensor** (27), and **icon** (31) were updated with new features and included as part of the refined concepts.

Figure 40: Set of low fidelity prototypes of the top-rated concepts
7.1.3.2 Concept Evaluation Workshop Results

Of the eleven concepts showed to DFG staff during the workshop, bump obtained the greatest number of blue votes (6) rendering it the favorite concept among DFG staff. As FT2 commented “the concept seems to integrate features which would be valuable for the dogs, especially having it disappear into the wall, and for clients who because of their disability sometimes struggle to give rewards in a timely manner”. It was closely followed by boink which obtained 5 blue dots and about which FT3 commented “this one might be easier for the dogs to use since its activation does not seem to require that much force, especially because some dogs are much gentler than others; however, I wonder if it will not be mistaken for a toy, especially because of the textures and then end up with the dog playing with it as opposed to using it as a device”. Strip was the workshop participants’ third favorite, which obtained 4 blue dots and about which PT2 commented “I like how the concept gives the dog a much bigger target area which could adapt to their height, the buttons we use right now are sometimes hard to reach or very small, making it hard for the dogs to target. I don’t know about the light feedback and wonder if it will not be in their face and maybe cause them to be afraid?”. Carrot was voted as the concept with the most potential, having received 3 green dots and receiving comments such as PT3’s “I like how the design is based on a behaviour dogs like to carry out but I wonder if teaching them to return the ‘carrots’ back to the stand will be an issue”; I2 also commented “they will think of it as a toy and begin to use it as such”. The concept deemed most likely to help the dogs perform better and the one that workshop participants would have liked to train with was bump obtaining 4 blue and green votes and receiving comments from most trainers similar to that of FT1, who said “seems like the one that is easier to train and which the dogs might like to use because of the movement….I worry about the treat dispensing and if then the dogs will be constantly pushing it in order to get the treat, but nevertheless the design itself is good because it tells you when it has been activated”.

7.1.4 Discussion

As the results show, the concepts provided a broad and diverse range of potential designs for the next iteration of controls, with some of the concepts pushing the conceptualization of these towards novel solutions which did not look or feel like any
Currently available product (e.g. carrot, and shin). This resulted in some of the concepts receiving mixed reviews from the trainers, and lower scores in their evaluations revealing an apparent tension between the degree of innovation put forth by the concepts and their actual usability. The following sections discuss this and other issues in more detail.

### 7.1.4.1 Work Versus Play

Based on our understanding of MADs as users, there seemed to be an opportunity to integrate dogs’ playful nature into the design of the controls. In fact, during the ideation phase, I explicitly designed features that would require the dogs to perform playful behaviours during their interactions. In fact, in the heuristic assessment of the initial series of sketches, those which afforded dogs playful interactions received higher scores. However, once shared with the trainers, these concepts quickly became problematic, as the question arose as to whether their mode of interaction could be accurately interpreted by the dogs to be one of playful interaction but not of play. As I2 commented “you want them to like what they are doing but not so much as to play, because when they play they are not working and really don’t think about what they are doing, they are not thinking about a command or a task, they are just playing”. Hence, the issue of work versus play in regard to MADs’ active interactions became important to consider. On the one hand, why not test to see if playful interactions might improve MADs performance by taking advantage of the fact that their behaviours would not have to be trained when carrying out tasks? On the other hand, because we are just beginning to gain an understanding of the MAD UX, would a design that makes the distinction between work and play less apparent also make evaluating its performance more challenging? Deciding on a design direction required reflection upon such questions, which in turn required the concepts to be contextualized within the current research constraints. **Hence, it seemed wiser to develop designs that help MADs to clearly distinguish between work and play, and that reduce the number of variables that could affect our understanding of their UX.**

### 7.1.4.2 The Value of the Trainer’s Feedback

The concept evaluation workshop enabled the trainers’ valuable insights to emerge and their perspective to be included as part of the concepts’ evaluation. For example,
considering the discussion above, the concepts that enabled playful interactions would have probably been chosen as ones to develop further, with only their positive aspects being considered and not the challenges they could pose for MADs. For another example, if not for the trainers’ feedback, I would have overlooked the effect of some of the concepts’ features for the human partner, moving forward with concepts such as icon or shin which could have caused potential harm or alienated some users. Furthermore, without the trainers’ input, I would not have considered the impact of certain concepts on MADs’ confidence, as with proxima and reset, whose use required MADs to understand the position of the device in order to activate it. This is not to say that MADs could not be taught to use such devices; but considering the dogs’ small training window (§5.2.4.1) and the focus on creating a design whose use was founded on existing MAD training protocols, these would not be viable concepts for this research. Hence, the trainers’ expert feedback proved to be of great importance to the design’s development. While expert input is also important when designing for humans, interspecies differences when designing for animals confer building upon the experience and knowledge of experts even greater value. That said, the question then becomes how to manage expert feedback; because, while providing great insight into the animal user, it might also result in more conservative design solutions that aren’t as innovative and do not push the boundaries of how animals might interact with them.

7.1.4.3 Innovation Constraints

The discussion above draws attention to a common trade-off when designing for others, whether for humans or animals, and which consists in establishing a balance between the design’s degree of innovation and the project’s constraints. In this case, the research was limited by the 3 years available to a full-time researcher. As a result, the dogs might have been provided with a design which might not give them the best possible UX, but which allowed me to accurately evaluate its impact on them. For example, as previously discussed in §4.4, for dogs, olfaction is the primary sense they use to make sense of the world; hence, it would make sense to use scents in the design of devices for canine use. But, if I were to use scent as a feature of the design, how could I accurately control this variable? Would I be introducing a feature which could result in an adverse effect for the dogs which would be difficult for me to identify, or would I be designing for the best possible UX? This is a hypothetical question as I am constrained by a human
understanding of how exactly dogs use scent to make sense of their world, and by our
different capabilities for smelling. Thus, it would make the sense not to use smell as a
feature. Or if I were to use scent, I would need to apply a similar approach to the one
used for training dogs and introduce scent in very small and incremental steps. Although
as designers we might want to improve the animal UX through novel solutions, until we
know more about the effects that our designs might have on them, innovation might be
better achieved through simpler solutions.

7.1.4.4 One Concept From Many

Although bump and boink were the top-rated concepts, they each were assessed by
the trainers as potentially presenting significant challenges for the dogs. Hence, the
design direction moving forward was not based on a specific concept, but rather the
features from the different designs that seemed to best respond to MADs’
requirements.

7.1.5 Emergent MAD User Requirements

Based on the data presented in the previous studies, a set of emergent MAD user
requirements are presented below.

- Due to the MADs’ playful tendencies, the devices’ design, although enjoyable
  for them to use, should not be too similar to other products which the dogs
  consider to be toys, as this would make the distinction between work and play
  harder for them to discern (e.g. boink, reset, and carrot concepts). Additionally,
  it should not require behaviours commonly performed during play, as this again
  would make the distinction between work and play harder for the dog to make
  (e.g. up & down and carrot concepts).
- Due to the partnership between MADs and humans, devices’ activation features
  should be designed so that it can be interacted with by both dogs and humans
  and not just one or the other (e.g. remote and proxima concepts). Additionally,
  the devices’ activation should not create socially charged situations (e.g. bark
  concept), where the use of the device might cause neighbours or other members
  of the family to complain.
- Due to the **vulnerable status of MADs’ human partners**, the device should not require a mode of activation that when carried out by a MAD could put them in harm’s way (e.g. shin concept). Additionally, the design should not create the potential for clutter (e.g. icon), as this would result in the dog having to do double work, using the device for activation, and picking up the device for safety; and the human potentially tripping on the device if left on the floor.

### 7.2 Second Iteration: Initial prototyping

The design’s 2nd iteration was based on the newly developed concept which aimed to provide MADs with a mode of interaction that afforded them clear and physical feedback related to its activation. It consisted in dual and single push-pad interfaces which when pressed activated a remote control which was wirelessly paired to a smart plug, to which a small home appliance was connected. The concept was built as a set of medium fidelity prototypes which were evaluated by 3 MAD partnerships who had them installed in their homes during a period of eleven days. Feedback was collected in the form of semi-structured interviews and user diaries. It is important to note that only one of the prototypes evaluated was durable enough to endure the eleven days of use, while the remaining prototypes were irreparably damaged during the course of the study. **Although the damage to the prototypes limited the data collected related to MADs interactions, it nevertheless provided a set of results that revealed valuable insights and further informed MADs’ user requirements. The following sections describe this in detail.**

#### 7.2.1 Participants

Participants included three MAD partnerships, all active clients of DFG who had been matched with their current MADs for a period of at least 12 months.

**Partnership 1 (MADH1)**

A black female Labrador Retriever (MAD1) born September 26, 2014, who had been partnered for two and a half years with a male in his 30’s (H1). The man had sustained an earlier injury which had left him wheelchair-bound with limited mobility in the lower
half of his body and full mobility in the upper half of his body. He lives on his own with MAD1 and receives regular visits from his mother.

**Partnership 2 (MAD2H2)**
A black male Labrador and Golden Retriever mix (MAD 2) born April 3, 2015, who had been partnered for a little over 2 years with a female in her 50’s (H2). The woman had limited lower body mobility that required the use of crutches for standing and walking while at home, and of an electric wheelchair while out. She lives on her own with MAD2 and is quite active in her community.

**Partnership 3 (MAD3H3)**
A yellow Labrador Retriever (MAD 3) born on April 16, 2011, who had been partnered for the last 5 years with a female in her 30’s (H3). The woman had reduced mobility, meaning she was able to walk around the home, but used an electric wheelchair while out. She lives with her mother and has daily overnight carers.

### 7.2.2 Methods
The 2nd iteration of design concepts occurred during the months of May and June 2019. These were developed using a series of methods common to interaction and ACI designers for identifying user needs and prototyping design concepts.

#### 7.2.2.1 In-home User Interviews
During the course of this iteration, a member of the Aftercare team and I visited the homes of the MAD partnerships on three occasions. The first visits aimed to establish a relationship with the partnerships and gain an understanding of their specific user needs through semi-structured interviews consisting of questions regarding the human partners’ background, previous and current MAD partnerships, activities related to the training of operational commands, their experience of the dog’s development in terms of performance, and their experience of establishing and nurturing a bond with their dogs ([Appendix 13](#)). Results were thematically analysed and used to define emergent MAD and human user needs specific to the partnerships ([§7.2.6](#)).
7.2.2.2 User Diaries

User diaries (Figure 41) were given to the participants during the second in-home visits and aimed to prompt human partners to record their and their dog’s daily interactions with the prototypes. Daily entries consisted of a set of questions in which participants were asked to: i. record their dog’s experience of learning how to use the prototypes, including if any specific features of the design seemed to affect their learning process; ii. record if the prototypes continued to work as intended and, if not, explain why and if they had been able to resolve the issue; iii. describe any events that might be considered especially relevant to their dog’s interaction with the prototypes; and iv. describe any improvements they felt could be made to improve the design. Additionally, the diaries contained a set of specific questions related to particular topics such as capturing participants’ first impressions of the design; asking them to use a linear scale to rate the design’s usability; and providing feedback related to the humans’ experience of use in terms of the overall value and impact the prototypes had on their relationship with their dogs and their daily activities.

![User diary examples](image)

*Figure 41: User diary examples (Days 3, 7, 8 and 12)*

7.2.2.3 Contextual User Interviews

During the third and final visits to the homes of the MAD partnerships, what was left of the prototypes was deinstalled and a series of contextual interviews carried out. These included questions regarding the human partners’ overall experience when using the prototypes, feedback on behalf of their MADs, and any other comments or suggested improvements to the design.
7.2.2.4 Prototypes

Based on the results of the 1st iteration, a new design alternative was developed. It first consisted in the construction of a series of low-fidelity functional prototypes to quickly test the viability of specific design features, for example, the design’s source of feedback, the lay-out of the internal components, and the functionality of the external components. It then involved the construction of two versions of the same design consisting of two round push-pads, one blue and one yellow. Informed by the results of the study presented in Chapter 6; and the fact that the controls were intended to be activated through the execution of a ‘nudge’ command, the height of the controls needed to be accessible to the MADs at ‘snout’ height. Hence, their internal components were designed to be operated wirelessly to allow them to be installed at a variable height based on the dog’s ‘snout’ and not on the proximity to, or the height of a socket. When pressed, the blue push-pad was designed to activate the on function of a wireless remote, and the yellow push-pad the off function. The remote was programmed to send a wireless signal to an electric plug which would turn the device plugged into it on or off. The second version of the design consisted of a single round push-pad that when pressed activated a wireless doorbell (Figure 42).

A total of six prototypes were constructed, four based on the dual push-pad design and two on the single push-pad doorbell design. To construct the push-pads, a store bought set of Velcro lined play paddles were outfitted with EVA foam and, in order to test if a physical indicator to the center of the push-pad made a difference for MADs’ interactions with the prototypes, one set was built using rope to line the edges of the pads, and the other without. Additionally, in order to create a higher level of contrast between the blue and yellow foam and the edge of the of the push-pads, their borders were painted black. The undersides of the pads were fitted with three metallic spring hinges placed in an equilateral triangle formation. A 5mm long length of the dowel whose tips had been cut at a 45° angle where glued to the back of the push-pads in a position that allowed them to act as levers which when pressed would activate the remote or the doorbell. Both the remote and the doorbell where encased in black foam core covers so as not to run the risk of distracting the dogs as an extra feature of the design. The push-pad(s), and the remote and doorbell, where then affixed to a black foam core base measuring 500mm width x 200mm height (Figure 43).
Figure 42: Progression of the construction of the design’s 2nd iteration
Top row - initial sketch; second row - functional prototypes; third row - the remote, its attachment to the push-pads, internal components, and its casing; bottom row – rope lined, underside and smooth push-pad
7.2.3 In-home Evaluations

The prototypes were installed in the homes of the MAD partnerships between May and June 2019. The first partnership MAD1H1 and MAD2H2 had two dual-push-pad prototypes installed from May 25th to June 12th and May 28th June 12th respectively. MAD1H1 had the flat pad prototype affixed to the refrigerator, and the with roped lined pad prototype affixed to the living room door. MAD2H2 had the flat pad prototype affixed to the refrigerator and the roped lined pad prototype to a cabinet located in the sitting room. MAD3H3 had two single push-pad prototypes installed from May 28th to June 14th, with the `flat pad located outside the patio door, and the rope lined pad affixed to the refrigerator (Figure 44). All home visit interviews and discussions were transcribed into a Microsoft Excel format and thematically analysed, summarizing the main areas of the interview content per participant.
7.2.4 Findings

7.2.4.1 In-home partnership interviews

The results of the interviews are summarized and presented by partnership in the following sections. Figure 45 shows the MAD participants.

![MAD study participants](image)

Figure 45: MAD study participants
Left - MAD1; centre - MAD 2; and right - MAD 3.

**MAD1H1**

MAD1 is H1’s second dog, with his first, having died prematurely of cancer. He was somewhat reluctant for MAD1 to also be a black lab-cross mix; but upon meeting her, he knew that they would make a good match. He described MAD1 as a highly expressive dog that consistently exhibits a range of vocalizations and looks as a means of communication. He considers her to be a “very clever dog that quickly picks up new things.” For example, he commented he had taught her to retrieve the phone from the living room and bring it to him in the bedroom on the first weekend after they were matched. In regard to task work, MAD1 can at times “be a little lazy,” a behaviour H1 has solved by teaching her a “help!” command which requires her to come to him immediately after which he asks her to execute the desired task work. MAD1 is incredibly driven and alert, which can cause her to be easily distracted and “struggle to stick to an activity or settle, because at times she gets overstimulated by the environment.” She “loves to retrieve and play Flyball” which (they) have been doing.

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24 Flyball is a sport in which dogs race against each other while jumping over a line of hurdles, to a box that releases a tennis ball when the dog presses on its spring-loaded pad.
recently.” She is “very independent, lays where she wants but at times comes close for a cuddle.” Regarding behavioural issues, H1 commented that besides a few instances of “frustration barking and whining that are sometimes directed at other dogs while on the lead” there are no other issues. MAD1 and H1 are a highly active partnership, thanks to H1 having a motorized bike which can go up to 15mph and which he uses for their daily walks. He describes MAD1 as providing him with a sense of independence and companionship that he values highly as his “days can get pretty mundane, so having someone else to take care of and that forces (him) to go outside for a walk is important.” He does not have any outstanding needs in terms of task work, commenting that “MAD1 and I have our routines and activities and she helps me out with what I need” although when further prompted he added “I do struggle sometimes to turn off the overhead light in the bedroom once I am in bed and there is the standing lamp in the living room behind the couch which is very hard for me to get to and which I rarely turn on.”

MAD2
MAD2 is H2’s second dog; who although she describes as a very high performer, she does not consider to be quite at the level of her first dog. This sentiment was echoed by the DFG staff member who was present at the interview which commented “if we could clone MADs, then H2’s first dog would be the one we would use.” That said, H2 has a very strong relationship with MAD2, describing him as “a highly communicative dog, that is constantly paying attention and alert to what I am doing at all times.” She continued by commenting that MAD2 is “a highly clever dog, I have taught him to do extra tasks that are hard for me to do that he did not know before, like pulling the drawers in the kitchen because I struggle with bending down. I adapted them with tape and rope so that he can pull on those and open the drawer. I also taught him to put trash in the recycle bin. He carries a can to the bin, uses his nose to pop up the lid, puts it in, and then uses a pull to bring the lid back down. He is quite a clever boy. He loves to work and learn new things and is always attentive to what I am going to ask him to do next.” She considered MAD 2 to most enjoy tasks which require him to push, nudge or help her undress. Additionally, H2 commented that H2 was a “highly determined”
dog that with proper support “maintains interest in activities and in the end succeeds at them.” MAD2 does seem to need quite a bit of reassurance from H2, and although not seeking as many cuddles from H2, does love to lay in among his giant stuffed animals. In regard to any behavioural issues, H2 commented that MAD2 does “sus and alarm barks at people and outside noises, but because we have our routine he only does it when someone which we don’t normally expect comes to the door.” She also commented that MAD2 “sometimes struggles with busier environments, looking for me to settle him… he has a phobia of anything that flies around him due to him having been bitten by bees as a young pup which I need to watch out for, especially in the summer.” She values the help and companionship MAD2 provides and is very proud of what he can do. She would like to be able to teach him to turn on the kitchen and living room lights as her current switches are impossible for MAD2 to reach.

MAD3

MAD3 is H3’s first dog and he, as H3 put it, “has changed (her) life.” MAD3 was described as “constantly checking in with (H3), making sure (she is) ok.” H3 added that “MAD3 gets very excited and loves other people, saying hello to everyone we meet.” They have recently been doing scent work25 together which he seems to enjoy. Regarding task work, H3 commented “… he loves to work and is always ready when I issue a command, sometimes he knocks something off the table just to pick it up and bring it to me so that I reward him…silly boy…it is also a way for him to look for attention which he is always doing, but he is very happy when I do ask him to do things.” His favorite tasks include retrieving and helping H3 undress. He loves to sit in front of the small fireplace in the living room, and also enjoys mouthing and sucking on toys; so much so that H3 has bought him a set of towels that are for used for this specific purpose. MAD3 can be easily distracted by birds, cats, other dogs and humans and sometimes loses focus on H3. He copes well in busy environments, even within the home where as H3 described “when my brother comes over, he has a 3-year-old daughter and she can be loud, but MAD 3 loves to play with her and is very patient.”

25 The sport of Scent Work is based on the work of professional detection dogs, employed by humans to detect a wide variety of scents and substances. In AKC Scent Work, dogs search for cotton swabs saturated with the essential oils of Birch, Anise, Clove, and Cypress. The cotton swabs are hidden out of sight in a pre-determined search area, and the dog has to find them. Teamwork is necessary: when the dog finds the scent, he has to communicate the find to the handler, who calls it out to the judge.
For H3, having MAD3 has equalized her relationships with others, as she described “he lets me do things when I want to do them and not have to rely on mum so much for things, also because of him I feel safe to go out on my own and he has let me be a part of the community, because even when I might not want to approach someone, he is so excited by other people that I end up in conversation!” She would like MAD3 to be able to turn her reading light on and off because it is located behind her chair and hard to reach. She also has a task light in her bedroom whose switch hangs from the nightstand and is hard for her to turn on.

7.2.4.2 User Diaries

Due to the limited number of participants, their individual circumstances and the fact that none of the prototypes remained usable throughout the eleven days of trials; with H1MAD1’s lasting for 8 days, H2MAD2’s lasting for 9 days, and H3MAD3’s lasting for 3 days, the results of the user diaries are presented as individual accounts:

MAD1H1

H1’s in-home prototype experience began with the prototype failing to withstand MAD1’s first interaction with it, during which MAD1, while trying to activate the push-pad with her paw, caused it to dislodge from the base and fall to the floor. Fortunately, I had taken a repair kit and managed to fix the prototype. Before reaffixing it to the door, the member of the DFG Aftercare team suggested we run through a few trials in which H1 would ask MAD 1 to nudge the prototype while holding it in his hands. This seemed to help a great deal, with MAD 1 quickly learning to use her nose as opposed to her paws to interact with the push-pads. H1 did not use the paper diary to record their experience, instead opting for daily email communications. The following are a few excerpts from these emails:

Day 1: “I’m using the command ‘touch on’ (for the blue pad) as I remembered we used it in Flyball. This would have helped earlier if I had remembered that. Occasionally she does want to bite the rope at the moment, I’m guessing this may be down to having a few roped chew toys. I think this process will be good for me and H1 as I like teaching her new things to do and working together obviously brings us closer together. I have had to stop from doing too much today as I don’t want to over treat her … and increase
her weight too much. As for the design, a few things come to mind: firstly, I like the different colour option, it gives a bright visual aid for her to work with. From a teaching aspect I’m thinking it would be better if the push pad were straight because at the moment I’m having to move her positioning to come at two different angles.”

Day 2: “I have found the prototypes to have a positive impact and value for me as I enjoy the training aspect of working with her…I also really enjoy the challenge of what I’m able to achieve paired with her accomplishment. The prototype has impacted my satisfaction and relationship with MAD1 as sometimes my day can become a little mundane. This is giving both of us something else to do.”

Day 3: “The prototypes have suffered damage, especially the targets (Figure 46), but I have been able to fix them with glue. I also reinforced the wooden dowel so that it would contact the remote better.”

Day 4: “MAD1 hasn’t fully grasped the aspect of ‘on’ and ‘off.’ I can guide her to the correct target, she is well adept at that now. If, however she does press the wrong one I can say ‘no!’ until she presses the desired target and then I give her a lot of praise.”

Day 6: “I give the ‘touch on’ command and MAD1 is successfully using her snout to press the targets.” (Figure 46). “She is enjoying playing this game together, so much so she will keep pressing when no command is issued thinking she will be rewarded.”

Day 8: “Unfortunately we are down to (the) ‘on’ (push-pad) for the refrigerator, and (the) ‘off’ for lights.”

Figure 46: MAD1’s interactions with the prototypes

Left and centre - the damage sustained by the prototypes when installed in the home of MAD1H1; right - MAD1 completing a successful trial when interacting with the dual roped lined prototype.
**MAD2H2**

H2’s experience of use with the prototypes began with her having very good initial impressions of the prototypes and being intrigued by how MAD 2 would react to the dual push-pads. She liked how big and obvious the pads were and thought the contrasting colours would make training MAD 2 easier, later commenting that MAD 2 had “Found them easy to use. Both of us enjoyed learning a new task, (with) no difference noted between different (roped and flat) versions.” The prototypes’ functionality was appealing to MAD 2 with H2 commenting “the big targets that moved when he touched them made it obvious to him he had done it correctly.” However, they quickly began to malfunction making for a frustrating interaction, which H2 recorded as “even when (he) pressed correctly they did not always work, making it difficult for MAD2 to understand that pressing a button resulted in (the) light going ‘on’ and ‘off’.” Additionally, in a similar manner to H1, H2 also found the angled design of the target surface to be more difficult for MAD 2 to activate suggesting that a design in which the “button faces the wall makes it easier to push it correctly from the widest possible angles of approach.” Despite these challenges she described the experience as a “Very enjoyable challenge for both of us, good fun to teach him and he enjoyed using it.”

**MAD3H3**

A few scheduling conflicts caused MAD3H3’s prototype installation to be delayed; however, the extra time enabled me to rethink the installation activities and include time for a member of the Aftercare team to spend a few minutes familiarizing and training MAD3 to use the prototypes. This greatly improved MAD3’s interaction with the prototypes allowing him to quickly figure out how to use them (Figure 47). Unfortunately, MAD3 and H3 had the worst performing prototypes, only lasting 3 days of use. As H3 commented “MAD 3 and I have been using the switches daily but are having real problems with them. The two of them are now broken; one fell off the wall and smashed when the Velcro failed; and the other’s hinge broke with use. MAD3 very rarely managed to make the bell ring due to the switch requiring a lot of pressure to depress the button, and also because the wooden dowel doesn’t often line up with the doorbell button.” In response, I sent her a dual pad rope version of the prototype.
Because of the delay in constructing the extra prototype, H3 did not get a chance to complete the diary; however, she did have this to say about the dual target design “MAD3 is doing really well with turning the lights on. It’s a much better design.”

Figure 47: In-home installation visits
DFG team member training MAD3 to use the prototypes before installation in the living room (right), DFG team member training MAD3 to use the prototypes before installation in the garden (left).

7.2.4.4 Contextual Interviews

Overall, although the prototypes clearly failed to meet MADs’ user requirements in relation to their robustness, they nevertheless provided the partnerships with what was unanimously qualified as an enriching and enjoyable experience of use. Some of the main insights gathered from the contextual interviews conducted during the final visit to the partnerships’ homes included:

- Pre-installation activities: H1 and H3 both commented on the need and value in carrying out training activities prior to the prototypes’ installation. H2 seemed to not regard this as important, with MAD2 quickly learning how to interact with the prototypes immediately after they were installed. This was likely due to H2 being more active in training MAD2 to do several tasks throughout the house, and to MAD2 exhibiting a lower level of arousal and excitement than MAD1 and MAD3, which might have helped him focus.

- New commands: all participants commented on how they had been expecting more guidance with regards to the commands that would be used to interact with the prototypes (e.g. if they were to use the ‘nudge’ command how would the dog know which pad to push?). This matter was briefly discussed during the
install visit to the home of H2, with the member of the DFG Aftercare team providing suggestions of what commands to use. Nevertheless, throughout the study, participants chose different commands for their dogs, with MAD1H1 using ‘touch on’ and ‘touch off’; MAD2H2 using ‘turn on’ and ‘turn off’ and MAD3H3 using the shorter ‘on’ and ‘off’.

• Colour preference for the targets: all participants reported that the dogs did not appear to display any preference towards the colour of the targets with all MADs successfully targeting both.

• Finding the prototypes: all participants agreed that the bright and high contrast colours of the targets made it easy for the dogs to find them within the home environment.

• Roped versus flat versions: H1 and H3 reported that MAD1 and MAD3 displayed no preference for either version of the prototypes; however, H2 commented that MAD 2 “seemed to be hitting the center of the button more” when using the rope version.

• Dual targets: although all the MADs were able to make sense of the task of pushing one target for the on command and another for the off command; all human partners reported that there seemed to be no added value to them doing so, with none of the MADs exhibiting an understanding of the functions or change to their environment as a result of their actions.

• Functionality of the targets: all participants commented on the feature relating to the amount of movement of the targets when pushed as providing the MADs with clear feedback on the result of their actions, and them enjoying coming into contact with the pads. However, the prototypes were not reliable in their operation of the remote, causing the dogs to experience frustration after having pushed the target, yet not having completed the command successfully. In addition, H1 and H2 both commented on the angle of the targets being harder for the MADs to target, resulting in the dogs having to reposition themselves to hit the target that could be reached more directly. As H1 commented “dogs take the path of least resistance, so MAD 1 is clearly going towards the yellow target she can approach directly, it is harder for her to target the blue one because she has no direct path to it and has to make this adjustment after
reaching it, so when I give her the command she sometimes pushes the easiest one first, even though by now I know she knows the command is to push the other one.”

- Teaching something new: all participants very much enjoyed teaching their dog a new task and, despite the technical issues of the prototypes, reported being deeply engaged in doing so.

### 7.2.5 Discussion

Due to the fragility of the prototypes, the findings presented above do not reflect a clear picture of MADs’ interactions with the design. However, the findings did result in a significant number of lessons learnt, related to the participants’ experience of use and my development as an ACI designer. The following section discusses these in detail:

#### 7.2.5.1 A Canine-friendly Design Does Not Guarantee Immediate Use

Although ensuring the animal knew how to interact with the device was considered as an important step when investigating animals interactions (§6.2.2.4), I did not seem to follow this step in the design of this study; assuming that the dogs would just know how to use the prototypes due to their design having been informed by their user requirements. I attribute this assumption to my human biases whereby for example, from a human perspective, changes from a single to a dual pad design might have been notable, but not significant; and the brightly and contrasting coloured pads would probably have been recognised as having different functions. Needless to say, I assumed a series of MAD behaviours when interacting with the prototypes which in some cases were instantly disproven, as was the case with MAD1. This is a significant lesson for my development as an ACI designer which underlines how, despite preparing myself to the best of my ability, I am not as hyper specific as a dog and will never be; therefore, I must remain hyper vigilant of how quickly my ‘humanness’ can override my responsibility towards the animal user.

#### 7.2.5.2 Command Use

When installing the prototypes, I realised I had overlooked the need to provide participants with specific instructions regarding the commands to use to prompt the
MADs to use the controls, mistakenly assuming that the “nudge” command would suffice. This of course was not the case, due to the pads having different functions, and hence, requiring different commands. This oversight promoted a discussion between me and the member of the Aftercare team while travelling from a home visit, during which we reflected on how the words commonly used as commands would appear to have a preexisting meaning for humans but not for dogs, leading us to hypothesize what, if chosen based on MADs’ characteristics as users, could have been the best words to use. Would using words which sounded very different from each other - while still providing an easy association for the humans - have made the learning process easier? For example, using the word “whale” for the blue on pad and “sun” for the yellow off pad, as opposed to just on and off? Or on, the contrary, would not being conventionally related to the function of the prototypes have caused the human partners to make more errors while issuing the commands and thus confusing the dogs? While my research did not focus on this issue, future work could investigate the influence of the words used as commands on the MAD UX.

7.2.5.3 Prototyping for Dogs

Based on the prototype’s failure to withstand the continued use by the MAD participants, the complexity of using and constructing prototypes for animal users is an important consideration. In the case of this research, a few key aspects seemed to emerge. As humans we understand the difference between a prototype and a finished product; with the words themselves implying the former to be a work in progress and the latter a finished work. This implication results in an almost automatic calibration of our behaviour when interacting with one or the other, probably being more careful or forgiving when interacting with a prototype as opposed to the finished product. When I was constructing the prototypes, I was thinking about how the dogs would interact with them and, even though I was familiar with previous prototypes developed for ACI research, I failed to consider how important a factor the choice of materials and construction methods would be. In my humanness I aimed for the prototypes to be robust. However, I don’t think I actually made the explicit distinction that for the MADs this was not a prototype or, for that matter, a finished product; it was just what they were being asked to interact with. Considering the above, one could ask if prototyping
for the animal user is even possible. Given species’ differing abstraction capabilities, are our measurements and observations of their interactions with a product that is not the finished version even valid? Does prototyping for animal users need especially detailed consideration as a tool for supporting the human researcher in refining a design and teaching them lessons about how animals interact; but does not necessarily provide us with evidence of the animal experience of the intended final product? Does prototyping for animals require the use of rapid high-fidelity prototyping techniques and small batch manufacturing methods to provide animals with iterations of finished products? Similar considerations have been addressed by previous ACI research. For example, in their work designing interactive systems for captive elephants, French et. al (2017) took a different stance to the questions posed above; instead arguing that “The less finished the piece of work, the more opportunities there are for others to participate in the design by contributing their own ideas, (a) flexibility (that) can also be extended to the animal users, so that they have the opportunity to make choices regarding the characteristics of the systems we design for them.” Both arguments would appear valid; however, based on my observations during the research, the use of prototypes by and with animals should consider their UX as research participants. Specifically, the intent behind their interactions with the prototypes which would help ensure that the right lessons are learnt, and accurate data is collected, and not, as was the case of this research, have the lessons learnt be arguably at the expense of the study’s participants.

7.2.5.4 Should They Understand the Command?

The dual push-pad design was intended to provide the dogs with a greater understanding of what the task of turning on a light entailed; however, none of the MADs were observed to notice the difference, with H1 instead reporting that MAD1 at times appeared somewhat confused during her interactions with the two pads. He hypothesized this as being a result of both pads seemingly representing the same task, as MAD1 did not seem to notice that as a result with her contact with the pad, the light had turned on and off. Hence, how could one fulfil MADs’ requirement for understanding the task they are carrying out? As presented by Mancini and Lehtonen (2018), this question could be addressed by “whether the specific set-ups and procedures in place, and the interactions these afford, allow (the canine research
participant) to make (her own) sense, express (a measure of) volition and exercise (some kind of) choice, thus enabling her to respond (through compliance, diversion or subversion) and inform (both providing information for and shaping) the design process.” Hence, alluding to the understanding not being the outcome of the interaction for the human’s benefit (e.g. light turning on), but instead, enabling the animal to understand that they have the ability to chose to interact with the device.

7.2.6 MAD User Requirements

Based on the data presented in the previous study, a set of emergent MAD user requirements are presented below.

- Due to the MADs’ different learning styles when first installing the device in a new environment it might be useful to provide them with direction on how to interact with the device.
- Due to humans’ different learning styles when first installing the device in a new environment it might be useful to provide them with direction on what their dog’s intended interaction with the device entails.
- Due to MADs’ use of their snout to target the controls, it seems that some kind of physical cue for where to target (e.g. rope or push-pad shape) might be beneficial.
- Due to MADs’ cognitive capabilities the simpler and more straightforward the design the better; hence featuring a single push-pad might be better than a dual push-pad design.
- Due to MADs’ sensory capabilities, the designs’ ability to provide them with a physical form of feedback (e.g. the push-pad’s movement) seems to provide them with an enjoyable experience.
- Due to MADs’ modes of interaction, the design’s operational parts should be easy to target and activate irrespective of the angle the MAD approaches them from.
- Due to MADs’ differing levels of task drive the devices’ designs should provide them with features that spark their interest.
• Due to MADs’ potential to be distracted, the devices’ design should enable quick interactions that do not demand their attention during extended periods of time.

• Due to MADs’ learning style, the device’s use should build on tasks which they already know how to execute.

### 7.3 Third Iteration: High-fidelity Prototypes

The third iteration of the design was informed by the results of the previous iterations and consisted of a set of nine cylindrical controls of three different sizes (90mm, 120mm, and 140mm) with a single push-pad with two different travel distances (5mm, and 20mm). They were constructed using 3D modeling and printing techniques, and internal electrical component design. They comprised a main cylindrical casing which - on one end - housed the push-pad, and - on the other end - terminated in a screw cap which gave access to the controls’ internal components. A transparent acrylic ring surrounded the push-pad, which when activated, caused a set of internal LEDs to turn on and create a light ring around the pad (Figure 48). The prototypes were tested at DFG facilities by 6 MADs nearing the end of their training. The following sections describe this process in detail.

![Figure 48: 3rd iteration of the prototypes](image-url)
7.3.1 Participants

Participants in the study included a total of six MADs proficient in carrying out a ‘nudge’ command (Table 6). Additionally, three full time trainers (FT1, FT2, and FT3) also participated, each with a different level of training, with FT1 being the most experienced, followed by FT2 and FT3.

<table>
<thead>
<tr>
<th>ID</th>
<th>Breed</th>
<th>Age (months)</th>
<th>Sex</th>
<th>Trainer</th>
<th>Training Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Labrador Retriever</td>
<td>18</td>
<td>M</td>
<td>T3</td>
<td>15</td>
</tr>
<tr>
<td>D2</td>
<td>Labrador/Golden Retriever Cross</td>
<td>36*</td>
<td>F</td>
<td>T1</td>
<td>14</td>
</tr>
<tr>
<td>D3</td>
<td>Labrador Retriever</td>
<td>16</td>
<td>M</td>
<td>T3</td>
<td>15</td>
</tr>
<tr>
<td>D4</td>
<td>Labrador/Golden Retriever Cross</td>
<td>17</td>
<td>F</td>
<td>T2</td>
<td>15</td>
</tr>
<tr>
<td>D5</td>
<td>Labrador Retriever</td>
<td>19</td>
<td>M</td>
<td>T1</td>
<td>14</td>
</tr>
<tr>
<td>D6</td>
<td>Labrador/Golden Retriever Cross</td>
<td>16</td>
<td>M</td>
<td>T1</td>
<td>14</td>
</tr>
</tbody>
</table>

*D4 was considerably older than the other participants due to her being a late arrival to training because of a health-related issue.

Table 6: MAD demographic data

7.3.2 Method

An initial series of low fidelity functional prototypes were created to define the size of the controls and the travel of the push-pads. The design was further refined as a 3D CAD model using the Autodesk Fusion 360 software, which enabled me to quickly develop different designs for the exterior casing and the push-pads. Some of these versions were shared with DFG trainers who proved specific feedback regarding the shape of the push-pad. Then, once a final design had been defined, the CAD model was developed to a level of detail good enough to communicate the design, and handed off to Vast, a technology and engineering consultancy located in London (http://v-a-s-t.co), who were commissioned to complete the technical details required for the prototypes’ construction. During the following weeks I visited the Vast offices for a series of meetings during which the prototypes’ components were further refined and a few tests of the different sized casings 3D printed. Additionally, in order to be able to develop the controls’ functionality without having to rely on store-bought components (e.g. the wireless remotes used in the previous study), a series of prototypes of the
control’s internal components were made, including a few iterations of the firmware developed by Vast which enabled the controls to be wirelessly paired to a smart plug and a light bulb socket (Figure 49). The final specification of the main parts of the prototypes included:

- **Cylindrical casings**: Printed using white PLA filament in three diameters; small (90mm), medium (120mm), and large (140mm), and two travel distances of the push-pads lengths 5mm and 20mm. The casing’s top edge contained an internal set of vertical ribs meant to guide the movement of the push-pad, and its bottom edge ended in a threaded finish meant to act as a screw in for the control’s lid. The casings’ white colour was intended to blend in with a typical residential wall.

- **Push-pads**: Printed using PLA blue filament in three diameters (84mm, 114mm, and 134mm) with a slightly convex (3mm depth) top edge and a set of vertical ribs around their circumference meant to fit into the main casings. The blue colour was intended to provide MADs with a distinct and contrasting colour that would support their identification of the pad as the control’s operational part, and to make finding the control within their working environments easier. The slightly convex shape was meant to provide MADs with a physical indicator to target the push-pad’s centre.

- **Light ring**: Laser cut out of 2mm acrylic, and glued to a shelf modelled inside the edge of the casings and set between the casing and the push-pad.

- **Lids**: Printed using PLA white filament in three diameters (90mm, 120mm, and 140mm) with its top edge finished in a threaded screw.

- **Base plates**: Printed using PLA white filament and consisting of a 2mm thick plate containing a set of screw holes and gussets to affix the control’s PCB board and switch holders.

- **Switch holders**: Printed using PLA black filament and used to affix the microswitch onto the base plate.

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26 PLA stands for polylactic acid, and is fully biodegradable thermoplastic polymer made of vegetable-based materials such as corn starch.

27 From here on out the controls will be identified as: 90_5 for the small and shallow version, 120_5 for the medium shallow version, 140_5 for the large shallow version, 90_20 for the small deep version, and 120_20 for the medium deep version.
• Base rings: Printed in PLA blue filament and consisting of a 2mm thick plastic ring with screw holes to affix the push-pad to the main casing while allowing it to move back and forth.

• Microswitch: Used to administer the controls’ power supply for the LED lights and the wireless pairing.

• Compression springs: Positioned between the base ring and the push-pad, with 3 used for the 90mm control, and 4 for the 120mm, and 140mm respectively.

• WiFi enabled plug, Sonoff S26, modified to work with the controls using firmware developed by Vast

• PCB board printed and assembled by VAST.

• Power source: 2 AA rechargeable batteries.

In order to expedite the construction process, printing of the parts was done by VAST and Kevin Dewar, the technical project office at the Open University’s Faculty of Science. It is important to note, that in order to guarantee the control’s portability, a self-contained battery-based power supply was chosen. This meant that in order to preserve power, the controls’ microswitch only activated the wireless signal when the push-pad was pressed, resulting in a technical trade-off consisting of a 2.85 second delay between the control being activated and the appliance (in this case, an overhead light) turning on. Although not ideal, at this stage of the process the control’s portability and the testing of the size and travel distance of the push-pad was more important than the activation latency.

Study activities included a discussion with the trainers carried out before the study and aimed at capturing their initial and resulting impressions of the prototypes’ design and performance as compared to that of the BPAC and the YPAC (§6.2). The different prototypes were tested by six MADs at DFG headquarters on October 17th and 18th 2018, during which they were observed executing a “nudge” command while interacting with each version of the prototypes. On the afternoon of October 18th a reflective debriefing session with the trainers was facilitated during which the complexities of measuring the MAD UX and the importance of the MADs’ level of confidence were discussed.
Figure 49: Design and development process of the prototype’s 3rd iteration
Top row: low fidelity prototypes to test the design’s size and travel of the push-pad; second row left and center: test print and assemblies of the controls; right: exploded view of the controls’ main parts; third row left: test prints; bottom left: controls’ internal components; bottom right: push-pad designs.
The observation and recording of the MADs’ interactions with the prototypes (Figure 50) was carried out in DFG’s main training room where the controls were installed at a height of 65cm off the ground determined to be an appropriate measure of MADs average ‘snout’ height, and wirelessly paired to a plug to which an overhead lamp - placed at an approximate distance of 150cm from the controls - was connected. Sessions consisted of the trainer issuing a “nudge” command when at a distance of 1-1.5m from the controls for a target of six trials.

![Figure 50: Study set up](image)

FT1 and MAD 2 interacting with the 120_5 prototype.

Because the dogs had not received prior training in using the prototypes, the trainers were given the option to hold a series of quick training sessions with the MADs prior to the trials. Out of the three trainers only FT2 and FT3 opted to do so with MADs 1, 2 and 3. The training sessions lasted approximately 4-8 minutes and consisted of the trainer holding one of the controls in their hands while rewarding the MAD for approaching, coming into contact and pushing the controls. The other three dogs, all under the care of FT1 were deemed to be fluent enough in their execution of the “nudge” command to not need any prior training. Additionally, all trainers were encouraged to terminate a session if they deemed that the dog exhibited any behaviours indicative of any adverse effects (e.g. avoidance behaviours such as laying down). Table 7 shows the total trials
(218) carried out by each participant for each control. Due to the MADs testing the 90_5 and 120_5 controls twice, more trials for these prototypes were recorded.

<table>
<thead>
<tr>
<th>Trials</th>
<th>MAD1</th>
<th>MAD2</th>
<th>MAD3</th>
<th>MAD4</th>
<th>MAD5</th>
<th>MAD7</th>
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<td>6</td>
<td>6</td>
<td>6</td>
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<td>34</td>
<td>42</td>
<td>38</td>
<td>31</td>
<td>214</td>
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</tbody>
</table>

Table 7: MAD prototype trials

The reflective debriefing session consisted in a discussion with the trainers regarding any aspects which they considered seemed to influence the MAD UX. Among these, one of the most influential was the dogs’ level of confidence; which was described as a fundamental trait for MADs to exhibit due to its potential to affect their learning, performance, and wellbeing while training. The results of the discussion are presented in the following section. They were used to inform the assessment of MADs’ level of confidence while interacting with the prototypes.

7.2.3 Data Analysis

Data analysis was done in three distinct phases; the first included the analysis of the initial discussion with the trainers; the second was the measure of the prototypes’ adherence to the relevant usability goals; and the third, based on the post study reflective discussion session with the trainers, introduced the dog’s level of confidence as an important aspect to consider when evaluating their UX.

Trainer survey responses were transcribed into a Microsoft Excel document where upon review, they captured the trainers’ expert feedback regarding the design of the controls. In relation to the controls’ adherence to the usability goals, due to the fact that the controls afforded MADs a very similar interaction (activating the control to turn on an overhead light as opposed to opening a motorized door) to those tested in Chapter 6 (§6.2.210), the same usability goals were deemed relevant.
The third phase of data analysis aimed to assess MADs’ level of confidence while interacting with the prototypes. Due to the individual differences among their levels of confidence and the ways in which they exhibited confident states (§7.3.4.4), it seemed appropriate to develop individual measures of confidence for each of the study participants. Additionally, because the influence of the trainer on the dogs’ experience can be significant (§5.2.4.2), the most experienced trainer’s (FT1) dogs’ trials were chosen for the analysis of their behaviours as they related to confidence. To develop the measures, FT1 and I discussed each MADs’ confidence baseline and the traits which FT1 had identified as revealing a heightened or lowered level of confidence for each participant. In the case of MAD2, FT1 commented “She is almost 100% confident, she passed her 16-week assessment at 13 weeks. Her love of food will make her do anything, and she is quite fearless; however, when her confidence is affected she gets frustrated and starts to mouth or bite the thing she is interacting with, she keeps trying but at some point the frustration wins over and she gets distracted.” MAD5 was described as being a dog who “Doesn’t really like learning and would much rather be playing around. She is very independent and alert when confident, however when she is challenged she disengages, starts pacing or walking around, or just being plain naughty and sometimes starts to huff and whine in frustration.” MAD6 was described as the least confident of the three, being “Always worried and overly reliant on me, looking towards me repeatedly. He also does not recover well from mistakes and at times just gives up. When confident he explores on his own and carries out the command but usually he is always looking for help.” As a result, the MADs’ confidence was assessed by recoding the behaviours that, informed by FT1’s input, would imply they were exhibiting heightened or lowered levels of confidence. Additionally, any instances of critical behaviours in which avoidance behaviours were present were recorded for all 3 MADs, including changes in their ear and tail positions, sitting, laying down, bowing or pawing at the control; and any vocalizations such as huffing and whining.

7.2.4 Findings

Findings evidenced that overall the trainers’ rated the prototypes favorably, with the 90.5 and 120.5 affording the MADs an improved experience of use. Overall, the controls provided the dogs with adequate usability, with some unusual results being
further explained by a series of critical incidents that evidenced other influential factors on the MADs’ individual scores. Additionally, the measure of the dogs’ level of confidence produced findings that confirmed the importance of this trait as one to consider when evaluating their UX. The following sections discuss these findings in detail.

7.3.4.1 Trainer Surveys

All trainers described the controls as simple, smart, and canine-friendly. They all considered the difference between the design of the BPAC and YPAC and the controls to be noticeably different, with FT1 preferring the design of the BPAC and YPAC, describing them as “seemingly simpler to use.” Trainers also thought that if the dogs had been asked to consider the difference between the designs, they would have noticed a significant difference due to their size, colour and shape. In regard to the size of the controls, all trainers preferred the medium control (120mm), thinking that the small control (90mm) and the large control (140mm) would be either too small or too big, with FT1 commenting “the small and medium sizes could be better for different breeds, while the large size could be used more during training with dogs that might struggle to accurately target a surface.”. Additionally, FT3 liked the idea of the different travel distances of the push-pad as features she could adapt to different contexts; commenting “depends on the dog, some more sensitive dogs might find the travel distance worrying, while others might find it motivating to push”; however, they agreed that if asked, the dogs might would have described the 20mm push-pad as noticeably harder to activate. This was echoed by FT1 who preferred the shorter travel (5mm) due to “the dogs having to make less of an effort for the same outcome, and thus getting treated quicker.” The light feedback was not particularly interesting to the trainers before the study; however, after the study all trainers agreed that the light, although mostly ignored by the dogs, had provided them with valuable feedback. When asked about what feature they would change, FT2 commented “I would add a more distinct sound and make them even more robust as our dogs can be forceful.” FT1 suggested a touch sensitive sensor-based push-pad, qualifying the clicking mechanism as “outdated although probably a cheaper solution.” FT2 and FT3 hypothesized that compared to regular light switches, the prototypes would improve the dog’s ability to turn on a light by a little; while FT1 rated them as improving it by a lot, explaining that
“the prototypes have only one direction for the same result, while light switches have an up and down. The single function seems to be simpler and better.” Additionally, FT2 commented “the accessibility of the controls made them much easier to use than the regular light switches.” FT1 added “most of the time with the current light switches it’s chance if they turn them on and off.” In regard to the number of errors, FT1 thought the controls would result in significantly fewer errors, due to the control’s accessible height. All trainers thought the prototypes would be easier to train, with FT1 commenting that “the 5mm was especially easy because there is a physical consequence to their action that is fairly easy to achieve.” Overall the trainers liked the prototypes and thought that the development of the design was going in the right direction.

**7.3.4.2 Usability Goals**

The following sections describe the results of the controls’ adherence to the relevant usability goals. It is important to note that the controls with the deeper push-pads (90_20 and 120_20) exhibited a considerable number of instances (31 out of 203) in which when pushed, the push-pad remained stuck and did not return to its initial position. In some instances, this was not a problem as with the dogs’ next push the push-pad dislodged on its own; however (8) instances did result in the trainer or me intervening and unsticking the push-pad on the dog’s behalf. The instances (11) in which the dogs’ second push did not dislodge the push-pad were removed from the overall tallies of their behaviours.

**Effectiveness**

With regard to the goal of effectiveness (Figure 51), the results show the most effective controls to be the 90_5 taking MADs an average of 4.83 contacts to activate, followed by the 120_5 with 4.91 contacts. The worst performer was the 120_20 which required an average of 10.63 contacts in order to activate; with 3 of the 6 MADs not being able to activate the control at all; confirming that the deeper travel of the 20mm push-pads seem to be harder for the dogs to operate. That said, the 140_5 control also required a high number of contacts (7.28), a result which was mostly observed to be due to the larger size of the push-pad; this required the MADs to target its center area in order to activate it. Additionally, it is interesting to note the difference between MAD1’s and
MAD2’s results; with MAD1 needing a significantly higher number of contacts than all the other participants and not being able to activate the 90_20 and 120_20 controls; while MAD2 required the lowest number of contacts overall. This is mostly due to MAD1 being an incredibly gentle dog, who although consistently coming into contact with the controls did not do so with enough force to open the door; while MAD2 was quite a forceful dog.

![Control Effectiveness (CE): average number of contacts per trial needed to activate the control](image)

<table>
<thead>
<tr>
<th>Control</th>
<th>MAD1</th>
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<th>MAD3</th>
<th>MAD4</th>
<th>MAD5</th>
<th>MAD6</th>
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</thead>
<tbody>
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<td>11.50</td>
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<td>10.63</td>
</tr>
</tbody>
</table>

Figure 51: Results of the prototypes adherence to the goal of effectiveness

**Efficiency**

In terms of the goal of efficiency (Figures 52 and 53), the quickest control for the dogs to operate was the 120_5, taking an average of 2.29s closely followed by the 140_5 (2.47s) and the 90_5 (2.51s). The controls with the deeper push-pads took the dogs a bit longer to open with the 90_20 taking 2.74s and the 120_20 3.63s.
With regards to *efficiency* as it relates to effort, the results are not as straightforward; mostly due to MAD 1’s significantly higher number of attempts with interacting with the 90.5 (13.7) and 140.5 (15.3). If we were to calculate the results excluding MAD1’s performance which seemed to be, as previously mentioned, a result of his gentle nature and not his ability to target the control; then the control which required the least attempts to operate were the 140.5 with an average of 2.5 attempts, followed closely by the 120.5 with 2.7 attempts, the 90.20 with 2.8 attempts, and the 90.5 with 2.9 attempts.
Figure 53: Results of the prototypes’ adherence to the goal of efficiency as the Average Energy to Open (AEO)

Safety

In regard to the goal of safety as it relates to error rate (Figure 54), all of the controls had comparable error rates ranging between 34% of the 90_5 and 45.5% of the 120_20. These results would seem to confirm that, irrespective of the controls’ size or travel of the push-pads, the dogs seemed to be targeting the push-pad as opposed to the controls’ sides or other elements in the environment consistently. The slightly higher scores of the deeper push-pads 90_20 with 43.7% and the 120_20 with 45.5% could be a result of some of the dogs experiencing some frustration in trying to push the push-pad all the way down in order to activate the control, and hence, possibly trying to target the edges of the control as an alternative.
Although these metrics help us assess the general usability of the controls; these results cannot be considered independently from certain critical incidents observed during the trials as they are fundamental to contextualizing these findings and better informing the understanding of MADs’ UX.

### 7.3.4.3 Critical Incidents

**Size Mismatches**

Based on the usability results presented above, MAD2 was highly successful in her interactions with the controls; however, when interacting with the 90_20 she seemed to struggle quite a bit with an error rate of 61.3% and requiring the highest number of attempts (4.8) and contacts (9) to activate. Upon further review of the footage, this was evidenced to potentially be attributable to the mismatch between her physical characteristics and the control’s size; as she was quite a broad dog, her snout seemed to be too large to fit into the pocket created by the push-pad’s travel, resulting in contacts with the control, which caused her whole snout to compress (Figure 55-right).
MADs 2 and 3 also seemed to struggle with the smaller size, opting instead to open their jaws before coming into contact with the pad and using either their top (Figure 55–centre) or lower jaw (Figure 55–left) to push, incidentally biting the control’s edge.

The Nuances of MADs’ Behaviour

MAD1 seemed to struggle the most to use the controls, attributed mostly to his gentle nature when coming into contact with the controls, which resulted in many attempts in which although he contacted the push-pad he did not do so with enough force to actually activate the control. However, when reviewing the footage, other relevant aspects were revealed. The first was the light ring feature, to which MAD1 was the only dog to noticeably respond to it; he appeared weary of the light, which seemingly affected his willingness to interact with the controls. In fact, during five trials, MAD1 was recorded repeatedly lightly touching the pad and seemingly expecting the light to turn on (Figure 56–left). Additionally, during a few trials, MAD1’s trainer FT3 preemptively rewarded MAD1 for approaching the control causing him to quickly turn his attention towards her and not continue to interact, and possibly activate the control. This might have been a result of FT3’s level of experience with training, or of her wanting her dog to be able to “get it”.

Figure 55: MADs’ snout-based interactions with the prototypes
Right: MAD1, 2 and 3’s struggles in operating the 90_20 control
The Larger the Target

It was during the dog’s interaction with the 140_5 control that the greatest number of paw-contacts was recorded (21) (Figure 59 centre and right). This could be a result of the dogs perceiving the larger surface as affording the use of their paws, which might allow them to be more forceful; alternatively, they might have preferred to use a less sensitive part of their body to make contact with the control.

![Image of dogs interacting with prototypes](image)

Figure 56: MADs’ interactions with the prototypes
Left - MAD 1 staring at the control waiting for the light to turn on; centre and right - MAD 5 and MAD 6 using their paws to activate the control.

7.3.4.4 Confidence

Overall, the trainers agreed that there was not a single or right way to evaluate confidence, with most dogs presumed to start out with a low level of confidence that is improved through training. Additionally, because assessing confidence requires the evaluator to make a series of assumptions that take into account aspects - such as their own biases and training knowledge, the dog’s training environment and the tasks being carried out - assessing confidence required a highly nuanced and holistic approach. As FT1 commented, “For each dog you start to know what causes them to lose confidence, and what they do when they are confident. For example, using devices that are hard for them to operate and that require them to push or pull really hard, overly complicated tasks or tasks that they are not good at, cause them to worry about making mistakes and lose confidence. When they are confident their muscles are relaxed, they investigate on their own and without fear, they persevere through challenges, and if they make a mistake they are quick to recover, quickly trying again.” The trainers identified a set of behaviours common to most dogs that suffer a loss of confidence, including avoidance behaviours such as laying or sitting down, walking around the
training area and disengaging from the task, being tentative when approaching the
device, lowering the position of their tails, or positioning their ears back and close to
their heads.

**MAD 2**

MAD 2 obtained her best usability scores while interacting with the 90_5 and her worst
with the 120_20. During her interaction with the 90_5 control she carried out a total of
14 trials that took her 29 attempts to complete; of these, she pushed the pad 18 times
with only 14 resulting in the light turning on. The footage of the trials lasted a total of
166s\(^2\) with the first 7 trials taking MAD2 141s to complete and the next 7 only 25s,
evidencing a vast improvement in her activation of the control. Furthermore, it was only
during the initial trials that MAD2 exhibited avoidance behaviours, with 10 instances
recorded of her biting the control, 5 instances in which she pawed at the control, 3
instances of mouthing the control, 3 audible huffs and 1 instance of walking around the
training area prompting FT1 to call her name to regain her attention. Mostly, MAD2’s
confidence level seemed to remain high throughout the trials, with her tail consistently
wagging at a similar frequency and in a mid to high position; her ears remaining forward,
and her overall posture relaxed. However, during her 5\(^{th}\) trial she visibly struggled,
recording a total of 10 attempts before activating the control, exhibiting the greatest
number of instances of biting and pawing at the control, and then disengaging from the
task. Despite the challenge, after having been called back by her trainer she quickly
refocused on the control and continued the session completing the remainder of the
trials. When interacting with the 120_20 control, her session lasted 116s; she completed
six successful trials after 29 attempts, of which 25 she pushed on the pad. During the
trial MAD2 appeared to be excited and engaged, continuing to wag her tail, as in the
previous trial, and maintaining her ears and body relaxed. However, she did paw at the
control a total of 12 times, bite it 6 times and huff twice. Despite these behaviours she
never stopped engaging with the trainer or the control, persevering through the
session, and quickly recovering from her mistakes and continuing to attempt to push
the control.

\(^2\) The total time of the trial was calculated as beginning when the trainer issued the first nudge command
and ending with the last successful activation of the control.
**MAD5**

MAD5, on the other hand, performed best when using the 140.5 control, taking a total of 43s to complete five successful trials. She remained engaged, wagging her tail at a consistent frequency in a horizontal position with her ears forward and body relaxed. She was recorded biting the control in 4 instances, but these appeared to be small bites to the edge of the control after having successfully activated it. On the other hand, when she used the 120.20 control, the session took her a total of 135s and only resulted in one trial in which she did managed to activate the control. During this time, she bit the control 14 times, pawed at it twice and disengaged from the trial walking around the room 3 times. Although her tail remained wagging, her body posture appeared to be less relaxed with her ears going back once and her willingness to continue to engage with the control significantly reduced; this prompted FT1 to heighten the tone and volume of her voice when rewarding successful attempts with prolonged “yaaaay” and “good girl!” verbal markers, and to reward her coming into contact with the control’s push-pad irrespective of her actually pushing it in. In the end, FT1 terminated the trial with the control, due to MAD5 becoming visibly frustrated.

**MAD6**

MAD6 performed best when interacting with the 140.5 control remaining engaged, with his tail in a horizontal position throughout his interactions with it, which lasted on average 35s. Conversely when interacting with the 120.20 control the session lasted 186s and resulted in only one successful trial which took him 22 attempts to complete. The session was terminated by FT1 who commented “I don’t think he is going to get it.” However, MAD6 did press the control 22 times, although not with enough force to activate it. During this trial he recorded 14 instances of looking back towards the trainer and 17 instances of holding his head close to the control but not interacting with it. His tail was in a lower position and his overall demeanor could be described as hesitant. Additionally, it is important to note that during the trials, whenever the MAD had visibly come into contact with the pad and pressed it, FT1 would reward the dog even though the light had not turned on. As all MADs struggling the most while interacting with the 120.20 control, instances of their confidence being affected were evidenced while they...
used this control, with MAD2 and MAD5 disengaging and MAD6 failing to activate the control.

7.3.4.6 Overall Results

Overall, the 120mm and 140mm control sizes did not seem to make a big difference for the MADs, with both sizes producing findings indicating that they were usable by the dogs, as opposed to the 90mm which, as discussed above, proved to be too small for some dogs to interact with. In regard to the travel of the push-pad, most dogs were able to more easily activate the controls with the shallower (5mm) travel; as opposed to the deeper push-pad (20mm) which required a more targeted push. These results serve to empirically confirm the specification for the travel of the push-pad for the controls; since they helped to clarify, that although some MADs seemed to enjoy the deeper push, most performed better while interacting with the shallow travel.

7.3.5 Discussion

As the results show, this iteration of the controls was able to withstand MADs’ active interactions; providing a clearer understanding of the UX they afforded the dogs. Although the findings indicate some improvement to their UX, a few considerations relating to the controls’ final design and the interactions between the dogs, the trainers, and the controls are discussed in the following sections.

7.3.5.1 Expert Feedback

The discussions with the trainers both before and after the study provided - as has been the case when integrating expert feedback during the course of this research – valuable predictions that were, mostly confirmed during the empiric observations of MADs’ interactions with the controls. Hence, the value and importance of expert feedback is further confirmed (a confirmation common to ACI, ID, and ethnographic research literature) and deemed a fundamental data source for the research. This, not only due to its predictive nature, but because of the wealth of tacit knowledge trainers have about the MADs which helped orient how their behaviour was contextualized during our assessment of their UX. However, what remains questionable is the best way to integrate expert knowledge in a systematic manner. Albeit focused on software design experts,
the work of Petre (2009) has investigated how to best capture expert knowledge with an emphasis on qualitative methods characterised as ‘cognitive ethnography’, which, as described by Ormerod and Ball (2000), involves the “observationally specific (using small-scale data collection based around representative time slices of situated activity); purposive (focusing on selected issues within existing work practices); and verifiable (validating observations across observers, data sets and methodologies) collection of data. In essence the approach during this research has mirrored the above, yielding descriptive accounts that inform not only the design of the controls for MAD use but also our approach to observing the animal user. So it would seem that the systematic inclusion of expert feedback in ACI research is based not necessarily on the method of inclusion but rather on the process of extraction. This means that feedback can be gathered in an observationally specific, purposive and verifiable manner in response to the particular aims of the research.

7.3.5.2 The Controls’ Usability Against that of the BPAC and YPAC, and the Measure of Usability

When directly compared, the controls’ adherence to the relevant usability goals far underperformed the results of the BPAC and YPAC. This could be attributable to a variety of reasons, a couple of which are discussed below. On the one hand it could be argued that the MADs’ familiarity with a SIAC, and thus a design that resembled it might have made the transition from interacting with the SIAC to the BPAC and YPAC easier for the dogs to understand, potentially indicating that the redesign of the controls might have been perceived as so different for the MADs, that they were required to learn a whole new interaction and not just the adaptation of a known interaction to a different design. However, based on what we know of MADs training experience, this explanation might be betraying what we also know about MADs abilities; yet, because we are just beginning to understand MADs interactions with technological devices, investigating the influence of design changes even when seemingly miniscule on the MAD experience might be pertinent. Another reason would be that, although seemingly better responding to MAD requirements, the actual design of the controls involved a greater number of moving parts, which as described in §7.3.4.2, sometimes malfunctioned affecting the controls’ usability. These reasons are not exhaustive in nature; yet they
could lead to a possible questioning of the validity of directly comparing usability results among different designs; because, due to the MADs non-verbal nature, we cannot guarantee that the cognitive processes resulting from their interactions with different designs are the same. Yet, on the other hand; we could also argue that in fact the direct comparison of usability results is valid, and that the issue, in this case, lies in the performance of the prototype which did not provide MADs with an error-free experience of use from a technical aspect. Or, it could be that the issue is not whether usability results are comparable across different designs, but rather what their role is in evaluating the MAD UX. As previously discussed (§6.2.6.2), when working with human users, the use of and validity of usability-based metrics is more straightforward and easier to integrate within the design process; conversely, when working with animal users it is not. Making it critical to balance the importance they are given towards our understanding of their UX; when in some cases (e.g. error-free functioning prototype) they might be considered as highly indicative of the MADs’ UX; while in others (e.g. prototype in development); they should be considered in relation to other measures (e.g. tail wagging behaviour). The above by no means aims to excuse or explain away the malfunction of the prototypes during this study; but rather to, in acknowledging their malfunction - a circumstance which is not uncommon during design development - to consider how best to deal with it in a way where the animal users’ interests are protective irrespective of the human-based errors during the evaluation of their UX.

7.3.5.3 The Influence of Confidence on MADs’ UX

Evaluating confidence was arguably a highly subjective assessment influenced by a considerable number of variables (e.g. trainer experience). However, when considered in relation to the control’s usability, a measure of confidence, even a highly subjective one, seems to help contextualize the way the controls worked for the individual dogs. For example, MAD2 was described by T1 as a dog who was 100% confident, a description consistent with her overall results during her interactions with the controls. This was further confirmed by her behaviours during her interaction with the 120_20 - the control she struggled with the most - which evidenced that despite her repeated failed attempts to activate the control, she maintained her interest in interacting with it, exhibiting perseverance and quick error recovery, both traits identified by the trainers
as those of a confident dog. On the other hand, MAD6 who was described as having the least amount of confidence did seem to display behaviours indicative of a loss of confidence during his interactions with the 120_20 control; during which avoidance like behaviours were displayed. 

What seems to emerge is a direct relationship between the dogs’ levels of confidence and performance (something the trainers’ had mentioned during my discussion with them); whereby more confident dogs albeit suffering from a degree of frustration while interacting with the controls, continue to exhibit proactive demeanours; while underconfident dogs that do not get as frustrated, seem to disengage from the task altogether. For future studies it might be valuable to develop a more systematic approach to measuring and evaluating MADs’ confidence levels.

7.3.5.4 The Control as a Mediator of the Interaction Between MAD and Human

Based on the discussion carried out with the trainers after the study, the light ring function of the controls, although seemingly not providing much value to the MADs was described as highly valuable by the trainers. This because, as FT3 commented “I was looking for the light to see if the dog had been successful and what kind of reward I should give them because if they had pushed the control but the light had not turned on I could give them a few rewards, but if the light did turn on and they had been struggling a bit then I knew to jackpot" they.” Hence the light was acting as a source of information for the trainers to provide the dogs with accurate feedback regarding the outcome of their interactions. In fact, recordings show that trainers were constantly looking for the light feedback prior to offering the dogs the reward associated with having turned on the light; in one instance FT3 rewarded the dog when the light had not turned on and then said out loud “oh, the light did not turn on, I shouldn’t have rewarded as much.” Additionally, the light ring helped the trainers reward attempts which could have remained undetected due to the position of the dog’s body. In other words, this design feature acted as a mediator between the dog and the trainer during the interaction helping reduce the potential for miscommunication by helping the trainers to accurately assess the outcome of the dog’s behaviour and give them timely

29 Jackpot is a term used in dog training which means that you give the dog a “jackpot” in rewards, either in quantity or value (e.g. cheese).
and accurate feedback based on their performance, while providing the dog with a clearer understanding of the result of their interactions.

7.3.5.5 The Delicate Balance Between Empathy and Bias as an ACI Researcher

Due to the small participant numbers during this research; I have focused on analysing MADs’ behaviours at an individual level. Doing so has created a tenuous yet palpable bond between myself and the MADs. Even though my actual interaction with the dogs was very limited; however, after reviewing so many videos of their interactions with the controls and at such level of detail I cannot help but feel like I have gotten to know them as individuals. For example, if I had been asked to briefly describe the MAD participants in this study my answer would have been: “MAD2 is fearless, remembers things, is really into it and quite forceful when interacting with the controls; while MAD3 is normal, although somewhat hesitant and not displaying any memorable behaviours.” On the one hand these highly subjective and non-scientific descriptions might serve as a tool with which to build empathy towards animals as users; conversely they might also influence my assessment of dogs’ behaviour and hence the evaluation of their UX; producing perhaps some sort of confirmation bias between the results of MAD2 who I described as fearless and MAD3 who I described as normal. Although, as a researcher I am tasked with remaining objective, because of the complex relationships we have with animals and our role as their interpreters during the design process, I do not know if remaining completely objective is even possible, or based on the example above, desirable. What I have learnt from carrying out this research is that this is yet another aspect of working with animals that should be explicitly acknowledged by the ACI researcher during their studies with and of animal users.

7.4 MAD User Requirements

Arguably the perfect design would be one which could afford every dog a great UX. However, offering such a design would either entail the bespoke design of each control for each user, or a highly customizable design. Regardless of what the perfect design might be, the study findings highlight the dogs’ capacity to respond and adjust their behaviour to the tools made available to them. Although these controls seemingly
provided MADs a better UX as compared to standard light switches, as discussed in §7.3.5.2 they are still far from perfect. Hence, based on the data presented in the previous study, a set of emergent MAD user requirements are presented below.

- Due to the MADs’ observed interactions during the study, the slight concavity of the push-pad seemed to help some dogs target the control; hence, for future iterations this design feature should be retained.
- Due to MADs’ varying levels of force when interacting with the push-pads; their sensitivity could be adapted to respond to MADs’ characteristics.
- Due to MADs’ varying levels of force when interacting with the push-pads; their travel should not be such that even forceful dogs struggle to activate.
- Due to MADs’ varying snout sizes, the devices’ operational parts should accommodate most dogs being able to interact with them without having to open their jaws to do so.
- Due to MADs’ varying performance when targeting the push-pads, the design of the controls should not make this a factor towards their successful activation.
- Due to the influence of MADs’ confidence on their interactions with devices, the devices design should not negatively impact MADs’ levels of confidence while interacting with them.

7.5 Chapter Summary

This chapter addressed the second supporting research question, srQ2 - (“What methods might ACI practitioners use to inform the design and evaluation of canine-centric interfaces?”), by presenting the evolution of the design of a series of smart control prototypes for MAD use during three distinct iterations. The first design iteration evaluated 16 concepts; and based on a heuristic evaluation of their adherence to the MAD user requirements, narrowed them down to 11 concepts. These were then evaluated by the trainers during a concept evaluation workshop to define a set of emergent MAD user requirements and identify various features that informed the design of the next iteration of concepts. The second iteration of the design included the development of a series of low fidelity prototypes constructed using store-bought materials and tested in the homes of three MAD partnerships. Although most of the prototypes did not withstand the prolonged use by the dogs, the feedback provided
by the MADs partners nevertheless generated valuable insights that informed the
design of the next iteration of the devices. The third iteration consisted of six controls
of varying sizes (90mm, 120mm, and 140mm) with two different push-pad travel
distances (5mm and 20mm) that were built and tested by 6 MADs nearing the end of
their training. These informed the refinement of the design for its final iteration
presented in the next chapter. Additionally, MADs’ level of confidence emerged as
another valuable aspect to consider and potentially measure for the evaluation of their
UX.
8. Evaluating a Design

This chapter presents the design and evaluation of the final iteration of a set of smart control prototypes for MAD use. The prototypes’ design was informed by MAD user requirements identified during the previous study. They were constructed using methods which included 3D modeling, 3D printing, and internal component electrical design. Data collection was carried out using ethnographic techniques including semi-structured interviews, user diaries and the recording of MADs’ interactions with the controls while installed in the homes of three MAD partnerships during a 33-day period. MADs’ UX was evaluated by applying the approaches developed throughout the previous studies including MADs MCPQ-R scores, tail wagging behaviour, level of confidence, their experience of use as described by their partners, the description of practical challenges during their interactions with the controls, the controls’ adherence to the interaction design principles, and their measure of usability. The following sections describe these in detail.

8.1 Participants

Participants in this study included the three MAD partnerships first described in §7.2.1.

8.2 Methods

8.2.1 Prototype Development

Based on MADs’ user requirements defined in the previous study (§7.4) the design of the prototypes was updated to include the following changes:

- Due to the 140mm-diameter control not being evidenced to provide any significant improvement to MADs’ performance over that of the 90mm and 120mm diameter controls, this size was eliminated from the set.
- Due to the 20mm travel distance of the push-pad causing some participants visible difficulty to operate, this was eliminated.
- A convex push-pad design was generated.
- A greater tolerance between the push-pad’s glides and the controls’ casing ribs was modelled so as to allow for a smoother movement.
• The push-pad was given a smoother finish.

The internal components of the control remained mostly the same, with some controls being programmed with new firmware that enabled them to be paired to a light bulb socket (Sonoff Slampher E27 LED WiFi). The CAD models for the prototypes were updated by Vast and printed at their offices. The controls were assembled by me; however, after a few assemblages had been completed, I noticed the push-pads were continuing to stick. Hence, I increased the tolerance, using a moto tool to increase the width of the channels and coated them with sprayable silicone to decrease any friction between the parts. Additionally, the push-pads were given a smooth finish by coating them in blue PlastiDip®, a durable multipurpose air-dry specialty rubber coating. A total of 8 controls were printed, of which four were 90mm in diameter and four were 120mm in diameter with each size having concave and convex push-pads options (Figure 57).
8.2.2 In-Home Data Collection

Each partnership was given two different sets of controls (Figure 58), with the first set installed in their homes for a period of 21 days, and the second for 13 days. During the installation visits, DFG staff members carried out a basic training session with the MADs and their human partners during which they demonstrated the basic training techniques for the controls. These were recorded and the footage sent to the participants for reference throughout the study. The first 7 days after the controls were installed were assigned as training days so as to allow the MADs to become familiar with and reach a level of fluency in using the controls. The controls were randomly allocated to each partnership. Table 8 shows the order of installation:

<table>
<thead>
<tr>
<th>Install</th>
<th>Control</th>
<th>Affixed to</th>
<th>Activates a</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAD1H1</td>
<td>1st 90mm concave</td>
<td>Refrigerator</td>
<td>Kettle</td>
</tr>
<tr>
<td></td>
<td>120mm concave</td>
<td>Refrigerator</td>
<td>Shell lamp</td>
</tr>
<tr>
<td></td>
<td>2nd 90mm concave</td>
<td>Refrigerator</td>
<td>Shell lamp</td>
</tr>
<tr>
<td></td>
<td>120mm concave</td>
<td>Living room door</td>
<td>Kettle</td>
</tr>
<tr>
<td>MAD2H2</td>
<td>1st 90mm concave</td>
<td>Refrigerator</td>
<td>Kettle</td>
</tr>
<tr>
<td></td>
<td>120mm concave</td>
<td>Living room cabinet</td>
<td>Overhead hanging lamp</td>
</tr>
<tr>
<td></td>
<td>2nd 90mm concave</td>
<td>Refrigerator</td>
<td>Kettle</td>
</tr>
<tr>
<td></td>
<td>120mm concave</td>
<td>Living room cabinet</td>
<td>Overhead hanging lamp</td>
</tr>
<tr>
<td>MAD3H3</td>
<td>1st 120mm concave</td>
<td>Radiator</td>
<td>Free standing lamp</td>
</tr>
<tr>
<td></td>
<td>120mm concave</td>
<td>Radiator</td>
<td>Nightstand task light</td>
</tr>
<tr>
<td></td>
<td>2nd 90mm concave</td>
<td>Radiator</td>
<td>Free standing lamp</td>
</tr>
<tr>
<td></td>
<td>90mm concave</td>
<td>Radiator</td>
<td>Nightstand task light</td>
</tr>
</tbody>
</table>

Table 8: Installation of the prototypes in the homes of the MAD partnerships
I visited the partnerships on three occasions; the first visit involved the installation of the prototypes, and an explanation of how to fill in the user diaries and the MCPQ-R questionnaires. The second visit involved the video recording on MADs’ interactions with the installed controls and the swapping of the controls for the replacement set. The third visit involved the recording of MADs’ interactions with the installed controls and a semi-structured interview, during which the partnerships were asked questions related to their overall experience throughout the study, and questions relating to the feedback they had provided regarding the design and function of the controls (Appendix 14). The interviews were transcribed into Microsoft Word files and their content thematically analysed, and then used to inform the final set of MAD user requirements.

![In-home interviews visits.](image)

**Figure 58**: In-home interviews visits.
Left - initial training of the 90mm convex control with MAD1 and H1; centre - MAD2 and H2 using the 120mm concave; and right – MAD3 mistargeting the 90mm convex control.

### 8.2.2.1 User Diaries

Each participant was provided with a user diary for the entire length of the study which consisted of a series of daily entries in which questions regarding their and their MADs’ experience of using the controls, specifically their design and function was provided (Appendix 15). The content of the diaries was transcribed into a Microsoft Excel format and thematically analysed, grouping the content by participant in order to capture a representation of their individual UX.
**8.2.2.2 Observations of MADs’ Interactions with the Controls**

In order to provide clear footage of the MADs’ behaviours and movements during their interactions with the controls, all observations were recorded from an overhead (camera mounted onto a boom pole), and a side (camera mounted on a small tripod) view. MADs were asked to carry out six command trials by their partners while interacting with the controls as installed in their homes. Unfortunately, some of the footage of these trials proved to be unfit for analysis, partly due to the lighting in the videos and partly due to the dogs’ complete movement being obstructed by an artefact within the home environment (e.g. furniture or decoration). However, all footage of MAD1’s interaction with all the controls was usable. Hence, MAD2 and MAD3’s UX was analysed based on their partners’ account of their experience; while MAD1’s UX was analysed based on her partner’s’ account of her experience and the footage of her use of the controls.

**8.2.3 Data Analysis**

In order to holistically evaluate the MADs’ UX as they interacted with the controls, the various methods developed in the previous studies were applied to record quantitative and qualitative measure of their behaviours. However, as mentioned above, due to some of the footage being unusable, in the case of MAD2 and MAD3’s interactions, some of the methods could not be used. Table 9 describes the methods applied and, based on the availability of footage, which ones were used to analyse the MADs' UX.

<table>
<thead>
<tr>
<th>Method</th>
<th>Data Collection</th>
<th>Data Analysis</th>
<th>MAD1</th>
<th>MAD2</th>
<th>MAD3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCPQ-R</td>
<td>Questionnaire filled out by their human partners.</td>
<td>Evaluation of the MADs’ personality</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>User Diaries</td>
<td>Completed by the human partners.</td>
<td>Thematic analysis of user diary content.</td>
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<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Heuristic assessment of confidence</td>
<td>Feedback provided by their partners.</td>
<td>Measure of dog’s confidence-based behaviours.</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Empiric assessment of confidence</td>
<td>Video of trials while using the controls.</td>
<td>Comparative analysis between the dog’s confidence-based behaviours (as reported by their partners) and their observed behaviours while using the controls.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tail Wagging</td>
<td>Video of trials while using the controls.</td>
<td>Data analysis of MAD’s tail wagging behaviours based on the results presented in Chapter 6.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empiric evaluation of the controls’ usability</td>
<td>Video of trials while using the controls.</td>
<td>Measure of the controls’ adherence to the usability goals of effectiveness, efficiency and safety.</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Methods applied to evaluate MAD participants’ UX

The controls were assessed heuristically, against the relevant interaction design principles described in §6.2.2.5, and empirically, against the usability scores recorded for MAD1. In regard to the software used to analyse the video, this study used the Elan 5.9 software, which provided better tools to analyse the multiple aspects of MADs behaviour. For example, the ability to use pre-defined codes that could be associated to broader themes and used to annotate the video according to specific instances or over a duration of time.

8.3 Findings

8.3.1 MCPQ-R Scores

Based on the discussion presented §6.1.4.4 MADs’ MCPQ-R scores are presented both as the result of their individual traits (Figure 59) and their overall behaviours (Figure 60). In reviewing their personality scores in this manner, I was able to analyse their behaviours more specifically, helping me make better sense of their tendencies, and hence their interactions with the controls. 📈

MAD3 was clearly the most extrovert, scoring 91.7% compared to the more tempered 77.8% score of MAD1 and 86.1% of MAD2. Overall, all three dogs were scored highly on being energetic, active, lively, and excitable; while MAD1 was scored the lowest (4) in terms of hyperactivity as compared to MAD2 and MAD3 (6); and MAD3 the highest in relation to restlessness (4) as compared to MAD1 and MAD2 who scored 2. In regard to motivation, MAD1 was scored the highest (83.3%), followed by MAD2 with 76.7% and MAD3 with 63.3%. Specifically, MAD1 and MAD2 scored on the higher side (5) with relation to the traits of perseverance, determination, and assertiveness while MAD3

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30 Elan 5.9 is a free annotation tool for audio and video recordings offered by The Language Archive (TLA) at the Max Planck Institute for Psycholinguistics in Nijmegen, The Netherlands.
scored in the middle range (4). In regard to independence, MAD1 scored the highest (6), followed by MAD2 (4) and MAD3 (3). All dogs received the same score in regard to tenacity (4). Concerning training and focus MAD1 and MAD2 both scored 83.3% with MAD3 scoring a bit lower at 75%. Overall all dogs scored highly (5) in regard to the traits of trainability, biddability, and reliability. While MAD1 and MAD2 scored highly (5), as opposed to MAD3 who scored moderately (4) in regard to the traits of attentiveness, intelligence, and obedience. All dogs received high scores in regard to amicability, a trait which is sought out in assistance dogs, with MAD1 and MAD3 scoring 83.3% and MAD2 scoring 80%. All dogs scored highly in regard to the traits of friendliness, easy-goingness, and sociability. While in regard to aggressiveness MAD1 and MAD3 scored highly (5); while MAD2 received a moderate (4) score. All dogs received moderate scores in terms of relaxation with MAD1 and MAD2 receiving a score of 4 and MAD3 a 3. In regard to neuroticism MAD2 scored the highest at 75%, followed by MAD1 and MAD 2 both scoring 58.3%. In regard to nervousness MAD2 was the most nervous (5), while MAD3 received a moderate score (3) and MAD2 a low score (2). MAD1 and MAD2, being more timid dogs, received a score of 5, while MAD3 was less timid and received a score of 4. MAD1 was the most submissive (5), closely followed by MAD2 and MAD3 with a score of 4. Finally, in regard to fearfulness, MAD1 was the least fearful with a score of 2, followed by MAD3 with a score of 3 and MAD2 with a score of 4.

![MADs' MCPQ-R Scores](image.png)
### Table 60: MADs' MCPQ-R scores by individual trait

<table>
<thead>
<tr>
<th>Extraversion</th>
<th>MAD1</th>
<th>MAD2</th>
<th>MAD3</th>
</tr>
</thead>
<tbody>
<tr>
<td>energetic</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>hyperactive</td>
<td>4</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>active</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>restless</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>lively</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>excitable</td>
<td>5</td>
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</tr>
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<table>
<thead>
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<th>MAD2</th>
<th>MAD3</th>
</tr>
</thead>
<tbody>
<tr>
<td>attentive</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>trainable</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>biddable</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>intelligent</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>obedient</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>reliable</td>
<td>5</td>
<td>5</td>
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<table>
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<th>MAD2</th>
<th>MAD3</th>
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<tr>
<td>persevering</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>independent</td>
<td>6</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>determined</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>tenacious</td>
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<td>4</td>
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<td>assertive</td>
<td>5</td>
<td>5</td>
<td>4</td>
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<thead>
<tr>
<th>Amicability</th>
<th>MAD1</th>
<th>MAD2</th>
<th>MAD3</th>
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<tbody>
<tr>
<td>friendly</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>easy going</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>non-aggressive</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>relaxed</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>sociable</td>
<td>5</td>
<td>5</td>
<td>6</td>
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<thead>
<tr>
<th>Neuroticism</th>
<th>MAD1</th>
<th>MAD2</th>
<th>MAD3</th>
</tr>
</thead>
<tbody>
<tr>
<td>nervous</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>submissive</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>timid</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>fearful</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 60: MADs' MCPQ-R scores by individual trait

### 8.3.3 User Diaries

Participants' first impression of the controls suggest that the controls were simple, robust, and canine-friendly, while not decorative or stylish; in one case they were described as bulky. All participants thought the design of the prototypes was significantly different compared to their current light switches and hypothesized that, due to their size, shape and installation height, they would be significantly easier for the dogs to use and quicker for them to activate. However, H2 and H3 quickly identified the effect of the delay between the control being activated and the light turning on as a feature that “would make it difficult for (MAD1) to associate pushing the switch to the light coming on.”, as H1 commented. None of the participants currently used their dogs
to operate their light switches; H1 did not need this kind of assistance, while H2 and H3 did not do so due to their current switches being unreachable for their MADs.

Overall, all participants thought the training of the controls had been easy to do; with H3 commenting “Having an experienced member of the DFG staff demonstrating the training was invaluable. I have watched the video a few times. MAD 3 finds the task easy and very quickly learned what to do.” Additionally, H1 thought the size of the controls had made them easier to train and described MAD 1 as having “taken to the buttons well, she is operating them at a high level even when I command her from the sofa” and H2 commented how “MAD 2 continues to enjoy being asked to use switches and is getting better at operating them correctly, so he is turning the light on and off most times now.”

In regard to the design of the controls, H1 and H2 preferred the larger size, with H1 commenting “the larger surface area seems to create more successful attempts”; while H3 preferred the smaller controls. H1 and H3 preferred the concave push-pads, with H3 commenting “concave is best as its shape encourages the nose to slide into the centre of the switch.”; while H2 preferred the convex due to MAD 2 being able to “hit it on the sides and the centre.” All participants thought the controls were a bit oversized in terms of their depth; causing them to protrude from the wall too much, with both H2 and H3 recording instances of bumping into them while moving about. However, H3 highlighted how their round shape meant that there were no sharp edges to cause her harm. When asked about the controls’ colours, H1 and H2 thought the blue acted as a visual aid for the dogs making them easier to spot within the home environment, especially during training. H3 would have liked the controls to blend in with the home décor a bit more and be completely white. However, by the end of the study she had noticed that the blue push-pad had made it easier for MAD3 to interact with the controls, and proposed that the pad could be mostly white, with a small blue dot at its centre. All participants liked the material of the controls, describing them as lightweight yet sturdy, also mentioning that the pad’s smooth finish made it easy to clean. In regard to the amount of pressure needed to activate the controls, H1 commented “The pressure needed is about right I think. Any stiffer would result in a lot of unsuccessful attempts. Any lighter and I think MAD1’s tail would activate it.” On the other hand, both H2 and H3 preferred a more sensitive design due to both their MADs having to exert
quite a lot of pressure and needing repeated prompting to operate the controls correctly. The controls’ sound-based feedback was described as useful to the dogs by H1, with H2 comment ing she “liked the control’s click feedback due to it being closely associated with the clicker training the dogs had done at DFG, enabling them to quickly associate it with success”. However, H3 mentioned that, although the sound was detectable by MAD 3, he sometimes appeared to be confused due to the control making a sound even when not successfully activated. In contrast to the feedback provided by the trainers during the previous study, none of the participants in this study found the light-based feedback particularly valuable. H1 commented that it did “not make a difference to MAD 1 or myself”, and H2 noted “the light feature was hard to use in normal lighting conditions, I don’t think we were able to perceive it.” All participants rated the push-pad’s travel as being sufficient and good enough to provide the dogs with clear feedback on having pressed it.

In regard to the impact the prototypes had on their daily lives and their relationship with their MADs, all human participants agreed that the experience had been a positive one for both, with all partners noting that the controls had caused an increase in the amount of interactions with their dogs, something they felt had helped to strengthen their bond. H3 commented “If I’m having a bad day and have to spend a lot of time sat still in my armchair, I can ask MAD3 to turn the light on/off if I want him to be busy and successful as opposed have him sleeping all day.” Additionally, when reporting about the value the controls had for them, all participants rated the controls as valuable. H1 scored them as ‘somewhat valuable’ because he usually operated the lights without MAD1’s assistance, but he also noted that “what has made it fun is being able to work with MAD1 and the controls...because I know she loves to do task work and this has given us something new to do.” H2 rated the controls as ‘valuable’, explaining “I have set some time aside every day to do this with MAD2 and he obviously enjoys learning new things and is so happy when he gets it right.”. H3 responded that the controls were ‘very valuable’, commenting that “The switches have enabled me to activate the lights whenever I want, meaning that my activity is no longer restricted by daylight. It’s also one less thing I have to ask mum to do for me, so it makes me feel like less of a burden. It’s given me the freedom to read whenever I want, I hadn’t realised how frustrated I
was having to wait for someone else to turn the light on for me. It’s a fun way for MAD3 to use technology to improve my quality of life ... and why he is my hero!”

Regarding MADs’ understanding of the task, participants reported that their dog’s ability to do so had been significantly affected by the delay between the control being activated and the light turning on, with the overall consensus being that their current understanding was simply that using the controls meant receiving a reward. However, all participants thought that fixing the delay would enable the MADs to eventually be able to reach an understanding of the task.

All participants ran into a few technical challenges when using the controls. H1 needed a replacement control during his first week of use due to the original control not pairing to the plug in a consistent fashion. H2 120mm concave control was replaced during the third week of the study because the control was consistently sticking. H3’s 120mm convex control stopped working on the second day of the study, so she was sent a replacement; although this affected MAD3’s total training time, it did not seem to be an issue, with H3 noting “Within 1 hour of the switches being installed he had learned to follow the prompts to nudge the switch without me being near the switch.”

After having used the controls for few days H1 and H2 both described instances in which the controls seemed to stick, with H1 commenting “I’m conflicted with these new prototypes. Although the design is similar, the slight differences in the design have been overdone. It has created sticking with the control. This has caused failed attempts; however, the single button makes it simpler to use.” H3 seemed to have a few issues with the fact that her dog was not pushing on the controls with enough force to turn on the lights, so she had decided to change the command she was using, commenting “I’m looking at whether the word ‘push’ encourages him to push the switch harder than the word ‘nudge’ because I usually have to prompt him 2-3 times to press the switch hard enough for him to activate it.”

Overall all participants enjoyed having the control in their homes. In fact, after the study, all partnerships were given the control of their choice to keep in their homes for further use. H2 really enjoyed the challenge of working with and training MAD2 noting “I love seeing him happy and enjoying himself. It was enjoyable being involved in a project that should have positive long-term effects and benefits for the client partnerships.”
This sentiment was also expressed by H3, who said “The switch needs a few changes to the design but with those I can see it helping a lot of other DFG clients.”

8.3.3 MAD Partners’ Assessment of MADs Confidence

In terms of confidence, all participants described their dogs as being very confident while carrying out task work and being readily willing to try new things. When asked to describe how their dogs usually behaved when confident, H1 noted that MAD1 would look “alert and bright eyed, with a ready to work posture and upright tail.” When asked to describe what traits (besides the ones described above) he takes into account when assessing MAD1’s level of confidence, H1 reported that he looks for the immediacy of MAD1’s movement towards executing the task and the speed at which she does so, commenting that “she will keep going until it is right.” H1 also reported that he can’t remember a time when he thought of MAD1 as being under confident, instead commenting how she “always seems to get it or is up for getting it. But she can at times start to whine or make frustration noises, which is the closest I would describe her to not being confident.” H2 described MAD2 as confident when he has his “head up, tail up, bright, eager, alert happy, keen and wagging his tail”; and under-confident when he has his “head down, tail tucked between legs, and anxious, sometimes with his ears back and an unhappy expression while backing away or trying to hide behind me.” H3 reported a confident MAD 3 to be “looking directly at people, bright eyes, mouth slightly open, and tail up”; conversely, when under confident she described him as having his “head down, tail down, looking around or at me, touching me, trying to come into contact with me for support.” Additionally, based on the contents of the user diaries, H1 and H3 thought their dogs to be “very confident” when interacting with the controls, while MAD2 was described as “confident”. Overall, H1 described MAD1 as being very “at ease and not showing any hesitation when interacting with the controls since day one”; H2 replied that MAD2 “pushes up to them and looks at me for confirmation that he has got the correct task work., then happily pushes, wagging tail while looking for praise or treat to confirm he has hit it right.”; and H3 commented “MAD3 approached the switches immediately and was happy to try to use them straight away even if he didn’t know what they were for.”
8.3.4 Practical Challenges

The first challenge was encountered while identifying where to install the controls in the home of H2. Due to the lack of surfaces which would not suffer any damage from the installation of the controls, the control that would operate the kettle was installed on H2’s refrigerator. Although this location was only accessible for MAD2 from a head-on direction, it seemed to best allow him to interact with the control without having to reposition himself. When considering where to install the control that would operate the living room’s overhead light, the only possible option was to install it on a cabinet located in the living room, which provided enough space for MAD2 to position himself in order to activate it (Figure 61). A similar issue was encountered in the home of H3 and MAD3, where the absence of free surfaces on which to install the controls also proved to be a challenge. Ultimately, the choice was made to affix the controls onto the heaters in both the living room and MAD3’s bedroom. This would not have been an issue if the study had been carried out during the summer; however, we were entering the winter months; thus, due to the heaters being on, the controls’ adhesive began to fail requiring H3 to replace them during the course of the study. More importantly, though, was the fact that MAD3’s contact with the controls was at times so forceful that it resulted in the heaters being loosened from their attachment to the wall, ultimately causing H3 to remove the control from her bedroom.

Similar challenges occurred when finding a space to set up the recording equipment. Although some space could have been created, the purpose of the in-home study was to record MADs behaviours in their naturalistic settings which might have included slight changes to their home environments, but not a complete redistribution of the furniture or other objects. Additionally, when conducting in-home user research, unless an agreement between the researcher and the participants has been reached beforehand, it is implied that the degree to which one can adapt the environment to suit the research’s needs is limited.

Other issues emerged during the study related to the training approaches of the MADs’ partners. As well as being less skilled than the trainers, their ability to conduct training activities seemed to be influenced by their reduced mobility. For example, in the case of H3, the command for MAD3 to activate the control was issued from a reclining chair located about 1.5m away from the control, a set-up which seemed quite similar to the
one that trainers and MADs had during the studies at DFG. However, in this case, if MAD3 exhibited any behaviours that showed he was struggling to activate the controls, H3 did not have the possibility of repositioning herself, coming closer to, pointing directly in front of, or touching the control to redirect MAD3’s attention towards it; instead she had to rely on vocal prompts or hand gestures issued from the chair. This would seemingly not affect the interaction itself, which still involved a command being issued for the dog to execute. However, during the analysis of the trials conducted at DFG in the previous studies, the trainers were quite active during the sessions, constantly repositioning themselves and moving their extremities in response to the dogs’ behaviours. Due to their reduced mobility, the challenges encountered by MADs’ human partners when carrying out task work with their dogs seemed to impact their ability to respond to their dog’s behaviour. Even though this is exactly the reason why MAD partnerships exist, human partners’ reduced mobility is an aspect of MADs’ working conditions that can potentially impact their UX, resulting in MADs’ being more reliant on the device itself to support them during the execution of task work.

Figure 61: Practical challenges
Left – H3’s kitchen where the 90mm convex control was installed; right - 120mm convex control set-up in H3’s bedroom.

8.3.5 Empirical Assessment of Confidence

Informed by H1’s inputs regarding MAD1’s confidence, the following behaviours related to her confidence levels were recorded and quantified:

- The duration of each trial (time from when the trainer issued the control to when MAD1 successfully activated it)
- The frequency and duration of her focus of attention during the trials, including H1, the controls, the floor, the researcher, or the environment
• Total time when her tail was in an upright position during the trials
• Vocalizations during the trials

MAD1 carried out a total of six trials while interacting with each of the controls for a total of (24) trials. These were captured during two separate visits to the home of H1. The first recording included MAD1’s interactions with the 90mm concave control installed on the living room door to operate a lamp located on a nearby shelf, and the 120 convex control installed on the refrigerator door to operate a kettle. The second recording featured the 90mm convex control installed on the refrigerator door to operate a kettle, and the 120mm concave control installed on the living room door to operate a lamp located on a nearby shelf.

On average it took MAD1 28.2s to activate the 120mm convex control; 28.6s to activate the 90mm convex control; 30s to activate the 90mm concave control; and 31.8s to activate the 120mm concave control (Figure 62). Overall, MAD1’s trial durations were consistent; with the trials that took longer to complete being the result of her requiring more than one attempt to activate the control (e.g. trials 2 = 6.2s, 5 = 5.7s, and 6 = 6.5s when interacting with the 90mm concave control), or due to the fact that she was focusing her attention on me (e.g. trials 2 = 6.5s when interacting with the 90mm convex control, and 4 (= 6.8s) when interacting with the 120mm concave control). Overall her level of confidence seemed to remain high with her speed of execution remaining consistent during the trials, with the shortest and longest average interactions with the controls only differing by (3.6s).

![MAD1’s trial duration in seconds per control](image-url)
In regard to MAD1’s focus of attention during her trials (Figure 63), she was mostly focused on the controls (46.69%) and H1 (43.11%), with the rest of her focus somewhat evenly distributed among the environment (4.14%), me (3.64%), and the floor (2.71%). These results evidence MAD1 to be mostly focused, 89.8% of the time, on the control or H1 suggesting that overall she remained focused on the interaction with the controls.

During the trials, MAD1’s tail (Figure 64) was in an upright position 40.72% of the time, in a horizontal position 40.35% of the time and in a low position 19.43% of the time. As a confidence indicator, it would suggest that MAD1’s confidence remained high during the trials. Upon reviewing the order in which her tail position changed throughout the trials, there seemed to be a pattern related to the specific behaviour being executed. For example, while seemingly alert and interested in H1’s prompt, her tail would be in a high position; then as she approached the control it would lower to a horizontal position; only to be elevated again once she was close to making contact with the control and while turning towards H1 for confirmation. Hence, although an almost even split between high and horizontal tail positions was measured, MAD1’s confidence seemed to remain high throughout the trials. Furthermore, these changes in tail position could be considered in relation to similar behaviours recorded in previous studies (§6.1.3.2) in which the MADs’ state seemed to change from one of anticipation during the before to one of excitement during the after phases of the interaction with the controls. In regard to a loss of confidence and recoded vocalizations, MAD1 was
evidenced to maintain her level of confidence with no vocalizations recorded during the trials.

8.3.6 MAD 1’s Tail Wagging Behaviour

In order to respond to the discussion concerning the application of the tail wagging ethogram to the observation of MADs’ interactions with technological devices (§6.1.4.5), MAD1’s tail wagging position (Figure 64) was calculated as a function of its duration rather than as the quantification of instances. Albeit based on a small sample size (24 trials), as discussed in the previous section, measuring MAD1’s tail wagging behaviour in this way provided a more nuanced understanding of her overall tail wagging position trends. Results revealed an almost even split between the percentage of total trial time during which MAD1 had her tail in a high position 40.22% and a horizontal position 40.35%, evidencing a low position only 19.43% of the time. This tendency towards a high or horizontal tail position as opposed to a low position would indicate a relaxed state, possibly a result of MAD1 being fluent in interacting with the controls and with knowing what to do (Beerda et al., 1996).

Based on the tail wagging ethogram presented in §6.1.2.6 MAD1’s tail wagging direction (Figure 65), MAD1 seemed to maintain an almost even split between left (62) and right-wagging instances (57); and a much lower tendency towards centre-wagging (13) instances. This proportion of instances in her tail wagging position is evidenced
during her interactions with each control. The even split between MAD1’s left, and right tail wagging direction would seem to indicate a balanced state between negative or positive stimuli (Quaranta et al., 2007).

In relation to MAD1’s tail wagging angle (Figure 66), MAD1 showed a greater number of 90° wags (55), followed by <45° wags (46), and 45° wags (31). This increase in angle might be attributed to her evidencing an increased state of arousal during the trials as a result of her expectation and excitement in receiving a reward. Additionality, her tail tip angle (Figure 67) evidenced a tendency towards a 90° (20 instances) and an almost equal split between a 45° (15 instances) and a <45° (14 instances).
8.3.7 Controls’ Usability Based on MAD 1’s Interactions

Based on the controls’ similarity to the prototypes tested in the previous study (§7.3.4.2), the metrics used to assess their usability as related to the goals of effectiveness, efficiency and safety remained the same. The figures below present these results.

With regards to the controls’ effectiveness (Figure 68) their overall performance was quite similar among them, evidencing only a 0.5 difference in the number of contacts required to activate the control between the control that required the greatest number of contacts, the 90mm concave with 1.67 average contacts, and the 120mm convex with 1.17 average contacts.

Figure 67: MAD1’s tail wagging angle and tail tip angle

Figure 68: Results of the controls’ adherence to the goal of effectiveness as assessed by MAD1’s behaviour
With regard to the controls’ efficiency as it relates to time (Figure 69), overall the controls took MAD1 a similar amount of time to activate with the most efficient (120mm convex) and the least efficient (120mm concave) being separated by a slight difference of 0.6s. In a similar manner, the amount of efficiency as the average energy needed to operate the control (AEO) as presented in §6.2.2.10 (Figure 70) was also consistent among the controls, with the 90mm convex and the 120mm convex both taking MAD1 a single attempt to activate, while the 90mm concave which received the poorest score, took MAD1 an average of 1.5 attempts to activate.

Finally, in relation to the controls’ error rate (Figure 71), the controls performed very well, with the 90mm convex and the 120mm convex control both having a 0% error rate,
while the 90mm and 120mm concave controls had a 10% and 11% error rate respectively.

Figure 71: Results of the controls’ adherence to the goal of safety as Error Rate (ER) as assessed by the measure of MAD1’s behaviour.

8.3.8 Heuristic Assessment of the Controls’ Adherence to Interaction Design Principles

The adherence of these final prototypes to the interaction design principles of perceivability, consistency, feedback, and affordance was assessed using the same metrics that had been used for the BPAC and YPAC prototypes. The evaluation involved the use of a simple evaluation matrix in which the devices’ features were plotted on its vertical axis and the relevant principles on its horizontal axis. When reviewing the intersections of the rows and columns, a simple rating scale between 1 and 3 where 1 indicated a low level of compliance, 2 indicated a moderate level of compliance, and 3 indicated a high level of compliance, was applied. The results are presented below:

<table>
<thead>
<tr>
<th></th>
<th>Perceivability</th>
<th>Consistency</th>
<th>Feedback</th>
<th>Affordance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max. score 18</td>
<td>Max. score 9</td>
<td>Max. score 9</td>
<td>Max. score 6</td>
</tr>
<tr>
<td>90mm and 120mm concave and convex smart controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90mm x 108mm and 120mm x 108mm</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Slightly textured off-white PLA enclosure</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Protruded (5mm) royal blue PLA concave push surface with PlastiDip® royal blue finish</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Acrylic light ring</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Spring loaded push surface (2 compression springs) requiring low to moderate pressure to activate 3 3 2 -

Friction sound emitted while being pressed, and audible “click” emitted when activated 3 - 3 -

Height adjustable - - - -

Totals 94% 100% 88% 100%

Table 10: Prototypes’ adherence to the relevant interaction design principles

8.4 Discussion

8.4.1 Are Some Traits of the MCPQ-R More Relevant?

While being a reliable tool to measure dog’s personality, the MCPQ-R only considers five personality traits, which do not necessarily cover aspects of personality which might be more relevant to investigating dogs’ interactions with technological devices (§6.1.4.4). During this study I reviewed the individual traits scored within the MCPQ-R as a way to gain a more detailed understanding of the MADs’ personalities. Doing so indicated that a potential approach to increasing the pertinence of the MCPQ-R as a tool for measuring canine personality during interactions with technological devices, might be consider which of the five traits might be more relevant for further investigation. For example, the trait of amicability, which measures how a dog responds to other individuals - be they humans, dogs or other animals (Ley et al., 2009a) - is highly relevant for MADs in general but might not be as relevant when it comes to the interaction with technological devices; with all MADs in this study receiving similar scores. Instead, it might be appropriate to focus more in depth on traits that are more relevant to such interactions, for example motivation and the specific adjectives (assertive, determined, independent, persevering, tenacious) that describe it; which in the case of this study revealed the largest difference among participants to be related to the trait of independence (MAD1 = 6, MAD2 = 4, and MAD3 = 3). In considering independence on its own, one might be able to look for patterns that help explain its influence the dogs’ overall score for motivation, potentially evidencing associations to the interaction itself; and possibly motivating conclusions such as “In order for MADs to be able to overcome the challenges that result from the mismatches between their
working environment and their characteristics as users, their degree of independence should be high.”

8.4.2 User Diaries

User diaries proved to be a valuable source of data collection, producing a significant amount of high-quality content that allowed participants to account - in their own words - their experience with the controls. Furthermore, by requiring daily entries of their interactions with the controls, the diaries prompted MAD partnerships to articulate nuanced aspects of their experiences with the controls, which in turn better informed my understanding of the MADs’ UX. Considering the challenges described above with regards to conducting research in users’ homes, since they could be completed at the users’ discretion, user diaries proved a valuable tool to enable data collection within the users’ naturalistic settings. However, because the accurate and clear reporting of animal behaviour is resource intensive, the current written format of the diaries could be reducing the amount of data recorded by participants. Therefore, future research could investigate the use of diaries for ACI research that enables participants to provide visual and acoustic data entry formats (for example, voice recorders to narrate the dogs’ experience as they interact with the devices).

8.4.3 Heuristic Assessment of the Controls Against their Empirical Evaluation

The heuristic assessment of the controls’ adherence to the relevant interaction design principles showed them to be highly compliant, with 94% adherence to the principle of perceivability, 100% adherence to the principle of consistency, 88% adherence to the principle of feedback, and 100% adherence to the goal of affordance. However, observations of the interactions indicate that the controls’ compliance to the above design principles did not always have the expected impact on usability. For example, in regard to the principle of feedback, the controls’ design was not the primary source of feedback used by the MADs to confirm their activation of the control, instead relying on the marker of success given to them by their partners. Hence, although compliant with the principle of feedback, when compared to their empirical evaluation, they would have scored much lower. Thus, although compliance with design principles is very
important, it does not guarantee that compliant design solutions will support usability in practice. Whether or not this is the case, it needs to be assessed empirically.

8.4.4 Confidence

Overall, when considering the specific behaviours used to assess MAD1’s level of confidence §8.3.5, H1’s prior assessment of MAD1’ being a highly confident dog was confirmed. Additionally, when considering MAD1’s usability-based results of her interactions with the control, it could be concluded that a high level of confidence would seem to play a role in helping dogs interact with a device successfully; a conclusion which was echoed by the MADs trainers (§7.3.5.3). Furthermore, the particular design of the controls’ seemed to not only help MAD1 maintain her level of confidence, but quite possibly help her to boost it; evidencing her interactions with the controls to be carried out with a high degree of usability while maintaining a positive affective state. These results could arguably reveal the maintenance or boosting of a MADs’ confidence to be a fundamental design goal when designing for a good MAD UX, as it would support MADs in assisting their human partners within their current, less than ideal, working environments, while promoting other behaviours that amount to a confident dog (e.g. alertness and perseverance).

8.4.5 The Systemic Nature of MADs’ UX

Overall the controls’ seemed to afford MADs’ a good UX, confirming that developing a design informed by and responding to their characteristics as users is key. Arguably, due to the absence of footage of MAD2 and MAD3’s interactions with the controls, their UX evaluation was not as accurate as that of MAD1’s, as less data was available to inform our understanding of their UX. For example, with regards to MAD3’s UX, H3’s user diary content suggests that he enjoyed using the controls and was quite adept at interacting with them by the end of the trial, with H3 reporting that MAD3 would sometimes “push the controls during the afternoon hours which is when I usually use the light”. Based on input from H3, the control which MAD3 seemed to better interact with was the 120mm concave, with H3 commenting “he seemed to like having the indent in the pad which helped him target the control better”. With regards to MAD1’s UX evaluation, H1 reported that the control that MAD1 most enjoyed using and performed best with was
the 120mm concave. However, based on the results of her empirical evaluation, including her tail wagging behaviour, usability, and confidence scores, the control she best performed with was the 120mm convex. This highlights the importance, for canine UX as with all UX research, of the use of multiple sources of data and particularly of empirical data to corroborate findings, including those gathered from expert feedback.

8.4.6 Unforeseen Value for the Partnership

Throughout the research, and more so during this last study, it has been very rewarding to discover the value that the controls had for the MAD partnerships beyond facilitating task work. For example, based on the feedback collected through the user diaries, and on previous input from DFG staff, people who suffer from mobility-related disabilities tend to have lives that are bound by routine, unforeseen health issues and, in some cases, a dependency not only on their dogs, but also on a group of family or professional caretakers. During this study, results evidenced that the controls installed in their homes impacted the lives of the partnerships in relation to these various aspects. In the case of H1, the controls gave him and MAD1 something new and enjoyable to do together to break their daily routine. H3 highlighted that, even on a day when she is not feeling well and can’t move as much, having the controls in her home allowed her to still offer MAD3 something to do. She further noted that the controls had made her realise how dependent she had been on her mother to turn on the light and how MAD3’s assistance with that task allowed her to feel a new sense of freedom. Finally, H2 commented on the value of the controls as they enabled her to interact more with MAD2 and helped strengthen their bond.

8.4.7 Unforeseen Consequences on the Partnership’s Context

Understanding MADs’ UX ecosystem not only helped me understand ways to influence it to improve it, but also helped reveal the secondary, and sometimes unforeseen effects (both positive and negative) that the design of technological devices might have on MAD partnerships. For example, by disrupting the habit of H3’s mother to operate the light on her daughter’s behalf might alter a dynamic in their relationship; one could speculate that, although she might feel happy for H3’s increased independence, turning the light on for her daughter might have been a way of showing her affection.
8.5 Study Limitations

Although I had the complete support of the MAD partnerships throughout this ACI research, conducting this while in their homes proved highly challenging. This was partly because each home environment is outfitted with different furniture and decorative elements, which made it difficult to install the controls and recording equipment, with the space in some of the testing environments being quite limited and cramped when three adult humans (human partners, DFG staff member, and myself), a dog, the camera set-up, and the existing furniture were present; resulting, in the case of this research, in some of the footage being unusable. Furthermore, home environments in general are quite challenging for researchers as you are not just stepping into a physical space where it is easier to maintain focus on the activities related to data collection, but one is also taking part in a series of social dynamics where appearing courteous towards the participants is paramount.

8.6 Final MAD Requirements

Based on the data presented in the previous study, a set of MAD user requirements emerged during the study are presented below.

- To accommodate MADs’ cognitive abilities, the auditory feedback provided by the controls should be a result of their activation. Therefore, if the controls’ internal components emit sounds which could be mistaken for feedback related to their activation, an alternate sound should be emitted by the control which provides clear feedback and confirms its activation both for the dog and the human.

- To accommodate MADs’ cognitive abilities, the delay between the interaction with the control and the result of its activation should be as small as technically possible.

- Due to MADs’ preference for snout-based interaction with the controls, the surface of the push-pad should be smooth and easy to clean.
Due to MADs’ human partners potentially **bumping into the control** and being hurt, the depth of the controls’ casing should be reduced as much as possible so that their protrusion from the surface they are affixed to is minimal.

**8.7 Chapter Summary**

This chapter presented the final empirical study of MADs’ interactions with a set of smart controls installed in the homes of 3 MAD partnerships for 33 days. The controls design featured two different sizes, 90mm and 120mm, with two different push-pad designs, convex and concave; with each partnership having the chance to interact with each type of control for a period of 13 days. MADs’ interactions with the controls were recorded in the form of user diaries filled in by the human partners, practical challenges reported by me, and the video recording of MADs’ interactions with the controls. A series of mixed methods, some of which were developed as part of this research, were used to evaluate MADs’ UX, including: user diaries and personality assessment by the humans; empirical measure of tail-wagging behaviour, confidence level, and usability; and the heuristic assessment of the controls’ adherence to the relevant interaction design principles. Unfortunately, not all the video collected was usable for analysis; therefore, although all of the MADs’ UX was evaluated, only MAD1’s UX was evaluated using the recorded footage of her interactions with the controls.
Phase 5: Outcomes and Conclusions
9. Outcomes

This chapter presents the final MAD user requirements as gathered throughout the research. It then addresses the third supporting research question srQ3 – (“What ethical implications arise when designing interactive canine-centric interfaces?”) by presenting an Ethical Toolkit for ACI Research and, based on the active ethical reflection carried out throughout this research, an example of how it was applied. The chapter concludes by presenting an Animal Centred Design Framework (ACDF) in which a methodological framework for ACI research is described that uses some of the methods developed and used throughout the research as procedural examples.

9.1 Final MAD User Requirements

Throughout this thesis, MADs’ user requirements were presented as a result of the research’s heuristic and empiric activities. Some requirements although important for the design of technological interfaces for MAD use are not specifically tied to the design of the controls developed here; hence, the following list presents a consolidated set of MAD user requirements for the design of smart controls, organized in a structure similar to that of the 6 Factors User Research Model (§4.2). They are presented by first describing the research which helped define or inform the requirement; the requirement (italicised in the text); and the design features suggested.

9.1.1 MADs’ Physical Requirements

9.1.1.1 Mode of Operation

Informed by MADs’ user characteristics as described in Chapter 4, and the results of the studies described in Chapters 6 and 7, which revealed snout-based interactions as being easier for MADs to carry out; the device should be easily operated by MADs while using their snout. Hence, the device’s operational parts should have a level of activation sensitivity that is easy for MADs to activate, suggested to be similar to that of the prototypes developed by Mancini et. al (2016). Be large enough to enable MADs’ to target them without requiring the opening of their jaws or biting, with the suggested part size being equal to or more than 100mm. If using a push-pad for the device’s activation, its travel distance should respond to MADs’ varying levels of force.
suggested to be between 5-10 mm; and have a physical indicator of where to target it, suggested to be a slight 3mm concave or concave shape.

9.1.1.2 Reachability

Informed by MADs’ user characteristics as described in Chapter 4; MADs’ user journey as described in Chapter 5; the results of the studies described in Chapter 6 in which ‘snout’ height was evidenced to be the most accessible height for MADs; and the results of Chapters 7 and 8 in which MADs’ angle of approach was evidenced to influence their UX; the device should be able to be installed within MADs’ easy reach, while allowing them to use their snouts to interact with it without having to jump or carry out movements that might cause them injury or discomfort. The device’s suggested installation height is between 21.5” - 24.5” from the ground, and in an area which allows MADs to approach it from a head on position.

9.1.1.3 Mode of Interaction

Informed by MADs’ user characteristics as described in Chapter 4 and the results of the studies described in Chapters 6 and 7; which evidenced MADs to be quite forceful in their interaction with the devices and prototypes; the device’s design and construction should be able to withstand all types of MADs’ snout-based interactions. Hence, the device and its parts should be made of materials that are durable and sturdy enough to withstand MADs’ interactive behaviours such as biting, gnawing, licking, bumping, and nudging.

9.1.2 MADs’ Sensory Requirements

9.1.2.1 Auditory

Informed by MADs’ user characteristics as described in Chapter 4 and the observation of MADs’ and their human handlers’ interactions with devices during the studies presented in Chapters 5,6,7, and 8, which revealed the influence of auditory-based feedback features to the successful activation of the device; the device’s audio-based features should be within an auditory range that is easily perceivable by both dogs and humans, suggested to be within the range of 200 to 4,000Hz.
9.1.2.2 Visual

Informed by MADs’ user characteristics as described in Chapter 4 and the results of the studies described in Chapters 6, 7, and 8, which revealed the influence of the device’s visually perceived features (e.g. colour and shape) on MADs’ UX; the device should be easily perceivable and locatable by both dogs and humans. Hence, it is suggested that the device’s design should be circular in shape and feature colours in the blue to yellow visual spectrum.

9.1.2.3 Taste

Informed by MADs’ user characteristics as described in Chapter 4 which described the potential influence of taste on MADs’ interactions, and the results of the studies presented in Chapters 6 and 7 of this thesis which revealed MADs’ preference for snout-based interactions; the device’s parts that are intended to be interacted with MADs’ snouts should be of neutral taste for MADs. It is suggested that the materials used for the device’s parts should be tasteless, taste neutral, or taste non-reactive; for example, closed cell, non-porous, or lightly porous synthetic or natural plastics.

9.1.2.4 Touch

Informed by MADs’ user characteristics as described in Chapter 4 which described the potential influence of touch on MADs’ interactions, and the results of the studies presented in Chapters 5, 6, and 7 of this thesis which revealed MADs’ preference for snout-based interactions; the device’s parts that are intended to be interacted with MADs’ snouts should be comfortable for them to use while coming into contact and pressing them. It is suggested that the device’s parts should be made of materials that are comfortable for the dogs to interact with while using their snouts, for example, materials which have a lightly textured or smooth finish and are described as warm (e.g. wood or plastic).

9.1.2.5 Olfactory

Informed by MADs’ user characteristics as described in Chapter 4; the device’s parts should not emit any distinct odours that might interfere or influence MADs interactions with the device. It is suggested that the device’s parts be made of materials that are odourless, or if emitting odour, be confirmed to be neutral or non-reactive for the dog.
9.1.3 Cognitive and Emotional Requirements

9.1.3.1 Learning

Informed by MADs’ user characteristics as described in Chapter 4 and the observation of MADs’ different learning styles as described in Chapters 5, 6, 7, and 8; **the device should be easy for MADs to learn how to use.** Hence, its use should be built on behaviours that MADs naturally perform, have already been taught to perform, or can easily perform based on their known abilities. Additionally, it should be able to be taught through a series of small, simple, and individual steps that incrementally teach MADs how to correctly interact with it and generalize its use. Furthermore, its use and general functionality should be simple and straightforward in nature, requiring little to no need for abstraction on the part of MADs, or the need for human intervention, and be able to be communicated with a single word that is distinct and can be clearly articulated by MADs’ human partners.

9.1.3.2 Device Feedback

Informed by MADs’ user characteristics as described in Chapter 4 and the results of the studies described in Chapters 6, 7, and 8 which revealed the importance of feedback during MADs’ device interactions; **the device should provide MADs with a mode of feedback that is clear, consistent and communicates the results of their interactions in a timely manner.** The device’s mode of feedback is suggested to use auditory-based functions as these were evidenced to be easily perceived by MADs, while building on existing training techniques such as clicker training. It should be emitted as quickly as technically possible after the device’s activation has been achieved and in order not to confuse the dogs, should be uniquely associated to its activation and not for example, the movement of its parts.

9.1.3.3 Rewards

Informed by MADs’ user characteristics as described in Chapter 4 and MADs’ interactions with devices as observed during the studies described in Chapters 5, 6, and 7, which revealed the influence and importance of rewards on MADs’ UX; **the device should support the timely and accurate delivery of rewards to mark MADs’ success.** It is suggested that the device should have features that either automatically deliver rewards or that provide MADs’ human partners
with clear and timely feedback to indicate when and if a reward should be delivered (e.g. light ring around push-pad).

9.1.3.4 Confidence Requirement

Informed by MADS’ user characteristics as described in Chapter 4 and the results of the studies described in Chapters 7 and 8 which revealed the influence of MADS’ level of confidence on their UX, the device’s design should enable MADS’ to interact with it in a way that maintains or boosts their confidence. It is suggested that in order to do so, the device’s use support MADS’ maintenance of focus (e.g. having a single source of activation), demand limited attention (e.g. requiring MADS the least amount of behaviours to activate), promote a state of eustress over that of stress (e.g. be consistent in its function), support MADS’ differing levels of task drive (e.g. have different degrees of sensitivity), be enjoyable for the dog to interact with (e.g. be made of materials that spark MADS interest), and be enjoyable for them to use, but not to the extent of being considered devices for play (e.g. having a form of physical feedback such as the one produced by the movement of the push-pad when pressed).

9.1.3.5 Training and Working Environments

Informed by MADS’ user characteristics as described in Chapter 4 and the results of the studies described in Chapters 5, 6, and 7, which revealed the influence of MADS’ working and training environments on their interactions with devices; the device’s design should remain consistent between MADS’ training and working contexts. Doing so should enable MADS’ to be quickly reminded of how to interact with it upon first use in a new environment. Additionally, the device should enable it to be installed in a variety of environments (training, public, home) and mounting surfaces (brick, drywall, concrete); for example, through the use of screw holes for fixed installations or surfaces for adhesive tapes such as Velcro for adjustable installations.

9.1.4 Social Requirements

Informed by MADS’ user characteristics as described in Chapter 4 and the observations of MADS’ interactions with devices described in Chapters 5 and 8; the device’s mode of interaction should not require MADS to perform any behaviours which might be considered socially negative by their conspecifics or human partners. Hence, the device should be installed at a height (§9.1.1.2) that reduces the potential of lowered or submissive postures and be operated
without the need to exhibit behaviours which might be socially charged; for example having the device’s activation be a result of barking.

9.1.5 Cultural Requirements

Informed by MADs’ user characteristics as described in Chapter 4 and the results of the study described in Chapter 8 which revealed the value of the interactions between MADs and their partners prompted by the controls, the device should support interactions that promote behaviours that help strengthen the bond between MADs and their human partners. Hence, if appropriate, the device’s activation should be a result of an interaction between MADs, their human partners, and the device; and have a task sequence similar to one in which the human partner issues a command which then prompts the MAD to interact with the device, and which results in the human partner or the device issuing the MAD a reward.

9.1.6 Human Requirements

Informed by the results of the studies described in Chapters 5, 6, 7, and 8 which revealed a series of human needs; the device should also support it being interacted with by humans. Hence it should be easy to install, operate, maintain, clean, and repair by either MADs’ partners directly, or if their disability prevents them from doing so, their caretakers; in a manner that does not cause them harm, and which responds to their characteristics as secondary users. The device should be made of the least number of parts that are the smallest possible size, while still being large enough to be easily handled by humans. When installed on a wall the device should not protrude more than 80mm. Furthermore, it should provide humans with clear and timely feedback that is perceivable even when not in their line of sight and which communicates the result of MADs’ interactions with it so as to support the accurate marking and reward of MADs’ behaviour. Audible-based feedback should be used as it seems to be the type most easily perceived by both MADs and humans (§9.1.1.1). The device’s materials, finishes, and colours should be within the visible spectrum for dogs while its appearance should remain aesthetically pleasing and suitable for installation within different environments including residential and public spaces.
9.2 An Ethical Toolkit for ACI Research (ETAR)

The third supporting research question (srQ3 - “What might be the ethical implications of working with MADs as our intended users?”) has been at the forefront of the reflections and choices made during the development and evaluation of the set of smart controls designed for this research. In thinking how best to address it, I considered providing a detailed description of these reflections and decisions; however, presenting them in this format although valuable, did not seem the best way to capture and share the results of having applied such an approach or how it shaped my experience as an ACI researcher. Most importantly, it would not provide other researchers with a framework that could help them apply and develop an active ethical reflective approach throughout their own investigations for and with animal users. Hence, by designing the ETAR, I was able to distill important aspects of my ethical practice during the research and package it in a format that would prompt ACI practitioners to clearly articulate the research’s ethical values and baselines, prepare them for the resolution of any unplanned situations during the research, and consider the impact of their decisions on the animal user during and after the research. The section below presents two examples of reflections I recorded and how they were later articulated as part of the ETAR.

Example 1: “I recently finished reading The Art of Memoir by Mary Karr (2015) and I believe there are a few similarities between memoir writing and animal-centred design (ACD). For example, as human designers we are the interpreters of the animals’ actions and needs throughout the entire design process; resulting in us having the power and responsibility of articulating the narrative of the animal user. A similar process was described by Karr, who stated memoir writing to be factual to a point and including the author’s fallibility as part of the proposal; meaning that a good memoirist admits and knows that their assertions and narrative might not be exactly as it happened and is shaped from their personal point of view. The similarity is not in the nature of the narrative; with ACD being based on scientific and systematic observations and records, and memoirs on memory. However, in both cases, the researcher or memoirist need to be aware of their fallibility and how their individual perspective might affect the narrative. They must rely on other sources of data or on investigating how the other people involved in the accounts remember them.” September 17, 2019
Example 2: “Mancini states “The way in which ACI researchers negotiate the ethical boundaries between their research and the systems in which their research might take place (e.g. farms, laboratories, zoos) is likely to depend on their knowledge and value system.” (Mancini, 2017b). Hence, ensuring that the researcher reflects on their own value system prior to and throughout the research is important; as it will not only clarify their own position towards the animal user, but will also help them inquire about and clarify the value systems of the other stakeholders involved.” December 10, 2017

The above reflections underline the importance, power, and influence of the designer during ACI research. Revealing the ability of the designer in framing and being aware of how their decisions are made, as a fundamental aspect to their ethical treatment of the animal user. Hence, by providing tools for ACI researchers to clearly and incrementally articulate their ethical beliefs and positions prior to the research they might more easily consider them throughout the remaining research. For example, by being asked to state their beliefs towards the animal as a research participant, an inhabitant of earth, or part of human society (Step 2. Of the ETAR).

9.2.1 Components of the ETAR

9.2.1.1 Establishing One’s ACI Ethical Baselines (aquamarine template)

This first template (Figure 72) provides, in its left-hand corner, a general description of the main steps of the toolkit. Step 1 - My Understanding of the Animal is Informed By - prompts the researcher to consider their understanding of the animal as a species and user of interactive devices by prompting a review of their data sources. Step 2 - My Understanding of the Animals’ Current Role Is - aims to help researchers consider and compare the roles an animal has within human society, their individual frames of reference and their role as a research participant. Step 3 - My Role as an ACI Researcher - focuses on the role of the researcher in relation to a series of aspects such as their influence on and over the animal during the research, their level of honesty in relation to their values towards the animal participant, their ability to care for the animal during the research, their level of integrity in regard to their commitment to help protect and uphold the animal participants’ interests, their ability to interpret the animal participants’ behaviours, and their willingness to reach compromises during the research.
**Estimating Your ACI Ethical Baselines**

<table>
<thead>
<tr>
<th>Process</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is your understanding of the animal?</td>
<td></td>
</tr>
<tr>
<td>2. How would you describe their role within the animal's environment?</td>
<td></td>
</tr>
<tr>
<td>3. How would you describe their role within the animal's environment?</td>
<td></td>
</tr>
<tr>
<td>4. How would you describe their role within the animal's environment?</td>
<td></td>
</tr>
<tr>
<td>5. How would you describe their role within the animal's environment?</td>
<td></td>
</tr>
<tr>
<td>6. How would you describe their role within the animal's environment?</td>
<td></td>
</tr>
</tbody>
</table>

**1. My understanding of the animal is informed by:**
Let your sources of data relate to how you have gained an understanding of the animal as a species, user of interactive devices, and research participant. (e.g., user research, personal experience, interacting with the animal, ACI literature, etc.)


**2. My understanding of the animal’s current role is:**
Consider the following questions and the different dimensions they include:
- How would these help you describe the animal’s role within human society?
- What are the implications of this role and its relationships for the animal?

**3. Who am I as an participant?**

<table>
<thead>
<tr>
<th>Inference</th>
<th>Honesty</th>
<th>Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you believe that your ethical responsibilities are compatible with the values of respect, tranquillity, equity, and freedom?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are you prepared to help protect and uphold the animal participants’ interests?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on your knowledge of the animal’s cognitive and communicative needs, how capable are you of accurately and clearly interpreting their behaviors?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 72: Template 1 of the Ethical Toolkit for ACI Research – Establishing Your ACI Ethical Baselines**

### 9.2.1.2 Establishing the Research’s Ethical Baselines (green template)

Comprising Step 4-6 of the toolkit, this template aims to help researchers’ address the ethical complexities of conducting ACI research, by prompting them to articulate the main aspects of the research and their potential implications for the animal as a research participant (Figure 73). Step 4 - *What and Why* - asks the researcher to state the main research question(s) and consider their overall intention, and relevance. Step 5 - *Where and How* - asks the researcher to consider their methodological approach in relation to its implications for the animal participant, specifically regarding its level of *inclusivity* in allowing the animal to participate in the research, *health and safety* in protecting the animal from harm, and enabling the animal to exercise autonomy. Step 6 - *Who* - asks the researcher to consider the research stakeholders, their roles, ethical responsibilities, type of involvement during the research, and their position regarding the values of respect, tranquillity, equity, and freedom.

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31 Relevance here refers to the balance between the risk and benefit of the research for the animal, and is based on the concept of relevance as presented by Mancini’s 2017 paper Towards an animal-centred ethics for Animal–Computer Interaction (Part 2 Ethical principles for animal centred research: 3. Doing research that is relevant to participants and consistent with their welfare) Mancini, C. 2017a. Towards an Animal-Centred Ethics for Animal–Computer Interaction. International Journal of Human-Computer Studies 98, 221–33.
9.2.1.3 Articulating One’s ACI Ethical Values (yellow template)

The third template (Figure 74) of the toolkit aims to help researchers articulate their ethical research values by considering their responses to the previous steps. Step 7 - Research Activity Scenario Planning - prompts the examination of the types of activities the animal is expected to engage in during the research and proposes that they be considered from the animals’ perspective, specifically regarding the level of relevance for the animal. Then, the researcher is prompted to consider if any of the planned research scenarios might raise ethical concerns related to the animal, and if so, how these might be dealt with, or if any aspects of the research plan can be changed or adapted to reduce the concern. Step 8 - Guiding Statements - aims to summarise the research’s ethical considerations by prompting the researcher to use a statement such as “In order to uphold the (insert value) of the (stakeholder) in relation to the animal participant, I will (insert action)” to articulate how they plan to uphold the values referenced throughout the toolkit including for example those of respect, equity, care, and integrity.
9.2.2 Using the ETAR

The formulation of the ETAR was done towards the end of this research; hence although I did not complete it prior to or during any of the studies; in retroactively filling it out, I was able to more clearly articulate my ethical values and inform the writing of this thesis. The results are presented in Appendix 16.

9.3 An Animal-Centred Design Framework (ACDF)

The ID process can be quite messy, sometimes being depicted as a squiggly line that begins in a state of high ambiguity and uncertainty, and as the process advances, incrementally and iteratively flattens into a state of clarity and focus (Figure 75).

Figure 75: Visualization example of the ID design process
In this way, the ACI process is quite similar to the ID process; yet it differs from it in that it also requires ACI practitioners to assume the role of researcher, designer, and interpreter of the animals' needs. Furthermore, depending on the animal, the researcher might also be required to assume other roles such as those of domesticator, caretaker, conservationist, or healthcare provider. Additionally, it requires the researcher to work with animal research participants who at times can be quite unpredictable. The above differences result in the animal-centred design process being highly complex. This is a circumstance which I experienced first-hand during the course of this research, even though I had a specific focus - the mismatch between MADs working environments and their characteristics as users – and was supported by previous research by Mancini et al. (2016). Hence, although various approaches and methods for ACI research exist, I wanted to develop a framework which could help other ACI researchers make sense of and navigate the complexities of the animal-centred design process, while still affording them the flexibility to adapt it to their own research. The result is the Animal-centred Design Framework (ACDF) (Figure 76) which proposes a series of 8 phases similar to that of a common ID process. Most phases include a heuristic and empirical research component which suggest methods which were either used or developed from scratch as a part of this research. All methods proposed in the ACDF are given as procedural examples that when adapted to other animals, appear to remain relevant; however the range of tools available to ACI practitioners is broader than the ones presented here; therefore as long as the aim of the phase is being met, the method used to do so is left to the discretion of the researchers. The following sections describe the ACDF in detail.

9.3.1 Define
The aim of this phase is to define the scope of the research, including its purpose, goals, objectives, research questions, and main stakeholders. Due to the number of established methods that exist for defining research, no specific approaches are proposed here, but it is suggested that methods which are commonly used in mixed methods research involving human or animal participants be applied. For example, methods such as those put forth by Cresswell (2017), Preece (2015), and Schoonenboom and Johnson (2017).
Figure 7. The Animal Centered Design Framework (ACDF)
9.3.2 Understand

The aim of this phase is to help ACI researchers reach a good enough understanding of who the animal user is. To do so, the framework proposes the application of heuristic and empirical approaches that focus on investigating and learning about the users’ characteristics, capabilities, motivations, and behaviours. For example, The Six Factors User Research Model (§4.2) which provides designers with a systematic structure to considering a series of factors related to the animal user. Additionally, in order to help ACI researchers reach an understanding of their users’ context(s), direct user observations are proposed; for example, the visualization of user journeys to facilitate the systematic identification of stakeholders, environments, and artefacts users commonly interact with (§5.1.2.1).

9.3.3 Frame

This phase has two main aims: the first is the definition of the methodological approach of the research and the second is the explicit articulation of the researcher’s ethical stance. When working with human users, a phase similar to the frame phase, sometimes known as the discovery phase is usually sequenced after the define phase (Rosala, 2020b, Kumar, 2012); however, because of the differences between animal users and human researchers, the ACDF proposes that the researcher first gain an understanding of the animal during the understand phase, as a means to inform their choice of methods. If the researcher is already familiar with the animal in question, then these phases could be interchanged; however, keeping the order of the phases as proposed here will help ensure that the methods chosen are the most appropriate for the animal user based on the most up to literature. With regards to the choice of methods, due to the challenges involved in designing for and with animal users, it is especially desirable that the methods chosen include both empirical and heuristic approaches enabling researchers to collect a wide variety of quantitative and qualitative data that can then be triangulated to help validate findings. In the case of this research, a series of mixed methods were chosen (§3.3), which allowed me to capitalize on the exploratory strengths of qualitative methods and the replicability and reliability of quantitative methods to address my main research question. Additionally, they allowed me to
rigorously investigate MADs’ interactions within the research settings and collect data from a variety of sources including MADs, their human partners, their trainers, and other DFG employees as a means to help validate the results. Some of the methods included for example, contextual inquiry (§3.3.2.2), multispecies ethnography (§3.3.2.3), prototyping techniques (§3.3.3), thematic analysis (§3.3.4.1), ethological data analysis (§3.3.4.2), and usability testing (§3.3.5.1). The second aim of the frame phase focuses on helping ACI practitioners articulate their ethical stance towards the animals they study. The ACDF proposes the use of Ethical Toolkit for ACI Research (§9.2); however, other methods which consider the ethical implications of the research on the animal might be applied here, such as those considered when discussing situational and in-action ethical approaches (§2.3.2.2).

9.3.4 Establish Requirements

This phase is equivalent to that of a typical interaction design process (§2.2) and aims to establish a set of user requirements that inform the design of technological devices for animal use. It is iterative, progressively integrating the results of each iteration as a means to further articulate and refine the animals’ needs into emerging user requirements. Many methods exist for gathering user requirements, and the ACDF highlights the methods used within this research, which proved helpful to mitigate researcher biases or assumptions. For example, the framework proposes that the gathering of requirements could be structured according to the 6 Factors User Research Model (§4.3), be informed by ID design principles (§2.2.4.1), usability goals and/or experience goals (§2.2.4.2 and §2.2.4.3), and empirically validated through the direct observation of interactions similar or equal to the ones under investigation (Chapters 6, 7, and 8). For the final list of MAD user requirements for this research please see §9.1.

9.3.5 Model

Based on the animal users’ characteristics and requirements, this phase aims to conceptualize what an ideal interaction would entail, so that such a conceptualisation could be used as a baseline by designers during their empirical validations of the animal user’s actual interactions. The methods used might vary based on the complexity of the interaction under evaluation. In the case of this research, MADs’ interactions with access
controls similar to the ones being developed were simple enough to be modelled using essential use cases (§6.1.2.5), and their interactions were observed during a comparative usability study between existing access controls and a set of prototypes previously designed by Mancini et. al (Mancini et al., 2016) (§6.2). However, a more in-depth task analysis technique might have been used instead of use cases to conceptualize a more complex interaction.

9.3.6 Design & Prototype
The design and prototype phases of the ACDF are equivalent to those of a typical ID process and aim to generate a large amount of design concepts that can be prototyped and tested with animal users (Preece, 2015). The methods used in this phase should be informed by the specific aim of the research, enabling researchers to investigate whether a design affords the animal user a good UX, by providing good quality data that can be used to inform the definition of user requirements and design specifications. In the case of this research, the methods used included concept generation matrices (§7.1.2.1) and different prototyping techniques (§3.3.3). It is important to consider the role of prototyping when researching the animal UX as it is not only their interactions with final products that we must consider, but also their experience as users with them during the research (§7.2.5.3).

9.3.7 Measure
As we have learnt throughout this research, in order to evaluate the animal UX, it is critical to first define what aspects of the animal users’ behaviour are going to be observed and recorded and how they will be measured. In the case of this research, measures included MADs’ tail wagging behaviour (Chapter 6) and usability behavioural metrics (Chapters 6, 7, and 8). As it turned out in our case, some behaviours might be difficult or impossible to clearly observe or record, for example MADs tail wagging during the in-home study presented in Chapter 8; some measures might result in a copious amount of data which requires significant resources to accurately analyse, such as MADs interactions with a SIAC presented in Chapter 6; while others might yield data that is not as informative about the animal UX as anticipated, such as the quantification of the time between when the command was issued by the trainer and the reward was
delivered to the MADs’ (Chapter 6, §6.1.2.3). Hence, as we have seen, it is important to define measures of observed behaviours such that the data collected can be accurately analysed, and that observation findings can directly and clearly inform emerging user requirements.

**9.3.8 Evaluate**

This phase has two distinct aims. The first is to promote the researcher’s ethical reflection on their level of adherence to the ethical stance articulated during the frame phase and assess how situations faced during the research were addressed and how the researcher’s understanding changed as a result. For example, a researcher might reflect on how the power dynamics that exist when working with animal users might have influenced their attitudes and actions during the research. In the case of this research, during the study of MADs’ interactions with the first version of the high-fidelity prototypes presented in §7.3, trainers were given the option to terminate a trial if the MAD seemed to exhibit any sign of frustration. Some trainers did in fact terminate a couple of trials during which the MADs were observed to visibly struggle, while other trainers and their dogs persevered through a few initial challenges which in the end resulted in a successful trial. During my observation of the trials I would keep a mental note of these decisions, reflecting on whether, if I had been the trainer, I would have stopped or continued the trial. Mostly my behaviour would have been the same as that of the trainers, yet there were a couple of instances during which I would have continued the trial. This exercise allowed me to become aware of the tension between my interest as a researcher in capturing data and my hypothetical attitude towards MADs as their trainer; making me reflect on how, if I had been the one with the power to terminate the trial, my attitude and actions might have influenced the research. The second aim of this phase is the systematic and systemic evaluation of the animals’ UX, both in terms of usability and affect; which could be done through the application of a mixed-methods approach that provides researchers with multiple sources of high-quality data that help overcome the challenges of working with and for animal users. In the case of this research, some of the mixed methods used included for example, the observation of MADs’ tail wagging behaviour which allowed for the non-invasive measure of MADs affective states (§6.1.2.6); the recording of MADs’ MCPQ-R scores which enabled a
deeper understanding of MADs behaviours based on their personalities (§3.3.5.2); and the testing of the prototypes’ usability which resulted in the systematic recording of MADs’ behaviours during their interactions with the devices (§3.3.5.1).

### 9.4 Chapter Summary

This chapter presented the consolidated list of MAD user requirements for the design of smart controls for MAD use. Additionally, it proposed an Ethical Toolkit for ACI Research (ETAR) developed as a means to address the third supporting research question (srQ3 - “What ethical implications arise when designing canine-centric interfaces?”). Finally, the chapter presented an Animal-centred Design Framework (ACDF) as a tool aimed at helping ACI practitioners plan and execute ACI research.
10. Contributions, Limitations, Future Research, & Final Remarks

This thesis explored the design of animal-centric interfaces for MADs that, informed by their characteristics and capabilities as users, afforded them an improved UX. In this final chapter, the main research and supporting research questions are restated, presenting the main activities carried out in order to address them. The research’s contributions to knowledge are summarised, its limitations considered, and future work proposed. The chapter concludes with final remarks expressing what this experience has meant to me as an ACI researcher, designer, and lover of animals.

10.1 Research Questions

The background literature reviewed in Chapter 2 evidenced that, even though a significant amount of research has been carried out within the field of ACI regarding canine-centric interactions, there remains a mismatch between the environments in which MADs operate and the devices they commonly interact with and their user requirements. The research reported here builds on existing work from the field of ACI, HCI, ID, and ethology to address its main research question:

“What kind of interfaces would need to be designed for MAD users in order to provide them with a good UX?”

To tackle this question, the research was divided into five phases, with specific activities carried out during each phase including:

Phase 1: Conceptual Framing
- The review of the relevant literature to this research (Chapter 2)
- The description of the research’s methodological approach (Chapter 3)

Phase 2: Understanding MADs as Users
(srQ1 “In order to design for MADs, what do ACI practitioners need to know about them as users?”)
• The review of relevant canine and MAD specific literature to understand MADs as users (Chapter 4)
• The planning and execution of two ethnographic studies carried out at DFG to understand MADs’ context of use, their UX ecosystem, and user journey (Chapter 5)

Phase 3: Observing MADs’ Interactions with Technological Devices
(srQ2 “What methods might ACI practitioners use to inform the design and evaluation of canine-centric interfaces?”)
• The empirical measure and evaluation of MADs’ affect and usability-based interactions with access controls (Chapter 6)

Phase 4: Designing for MAD Users
(srQ2 “What methods might ACI practitioners use to inform the design and evaluation of canine-centric interfaces?”)
• The design and development of a set of high-fidelity smart control prototypes for MADs’ use (Chapter 7)
• The heuristic and empiric evaluation of MADs’ UX during their interaction with a set of high-fidelity smart control prototypes (Chapters 7 and 8)
• The identification of a final set of MAD user requirements for the design of a set of smart controls (Chapter 9)

Outcomes and Conclusions
• The proposal of an Ethical Toolkit for ACI Research - (srQ3 “What ethical implications arise when designing canine-centric interfaces?”) - (Chapter 9)
• The proposal of an Animal-Centred Design Framework (ACDF) as a tool to help practitioners plan ACI research (Chapter 9)

10.2 Contribution to Knowledge
Given the complexity of the work undertaken and the limited number of research participants, there is no claim in this thesis of statistical evidence that supports a formal result for a proven method to design for or evaluate the animal UX. However, taking into account the process carried out for the design and development of a set of smart
controls for MAD use, findings show that adopting a UCD approach to designing for animal users can improve their overall UX. In particular, this research adopted perspectives, methods, and approaches from the fields of ACI, ID, HCI, and ethology, resulting in a series of methodological, design, theoretical, and animal welfare contributions to knowledge with regards to the design of technological interfaces for animal users. The following sections describe these in detail structuring them as learnt and produced contributions.

10.2.1 Lessons Learnt

Partly due to the nascent nature of ACI, new research within the discipline is bound to produce a series of lessons, reflections, and considerations that when captured constitute contributions for future research. The most significant that result from this research are described below.

The first contribution is the importance of developing prototypes while actively considering the animal users’ behaviours and characteristics. Even though I have a considerable amount of experience in designing and constructing prototypes, and I had designed the prototypes based on MADs’ characteristics, I grossly underestimated MADs’ actual use of the prototypes and did not consider how quickly they might be damaged or how forcefully some dogs would interact with them (Chapters 7 and 8). Hence, it is of fundamental importance when designing and constructing prototypes for animal users, to proactively try to embody the animal user to as a means to enable human researchers to better consider and evaluate their use of materials and prototyping techniques for ACI research.

Another contribution is the use of the viewing-hats technique (§6.1.2.4) as an approach to address potential coding biases during ACI research, which, due to the method’s requirement of role play, prompted the embodiment and articulation of different perspectives than my own to enable the more objective analysis of the research data.

The third learnt contribution is the importance of the visualization and definition of the MAD UX ecosystem (§5.2.4) as a means to more explicitly define the influence of its individual elements (artefacts, stakeholders and environments), and understand how they interact with one another and their overall impact on the UX. Followed by the articulation of the influence of the Advanced Training Stage (ATS) on dogs’ ability to
become MADs (§5.2.3) and its implications for future research (§10.34.5). Finally, the confirmation of the appropriateness of applying a UCD perspective to ACI research, which promotes the application and adaptation of methods that conform to the animal user and the research setting; and that are known to enable the systematic measure and evaluation of MADs’ behaviour, producing valid and rigorous results.

10.2.2 Contributions

Due to the product design component of this research, some of the contributions include methodological, theoretical, and tangible design components. The section below describes these in detail.

The development of the 6 Factors User Research Model (§4.2) which, based on the exiting 5 Human Factors Model (§4.1), led me to identify the need to include a 6th factor related to users’ sensory capabilities. The result was a more inclusive model for user research which considers the differences between human researchers and animal and human users with differing sensory capabilities.

The collaborative development of a combination of approaches which enabled the non-invasive measurement of MADs’ behaviour that was based on dogs’ naturally occurring behaviours; and which revealed a correlation between how dogs wag their tails and their personalities (§6.1.4.5). Specifically, the theoretical contribution of a tail wagging ethogram (§6.1.2.6) used to assess MADs’ tail wagging behaviour as an indicator of their affective-based states during their interactions with technological devices; and the application of the MCPQ-R to contextualize and investigate MAD participants’ individual personalities and their influence on their tail wagging (§6.1.4).

A first iteration of a Method for Evaluating Animal Usability (MEAU) (§6.2.2) in which a systematic process for evaluating a design’s adherence to the relevant design principles and usability goals was proposed. The development of the MEAU included a series of 11 steps which provide ACI practitioners with detailed procedural descriptions of how to conduct animal-based usability testing, adapt and reformulate human-centric design principles and usability goals to animal users, and measure and evaluate animals’ behaviours during their active interactions with technological devices.

Throughout the research, a set of heuristic and empirically derived user requirements (§9.1) was identified and applied to the development and design of a set of high-fidelity
prototypes of smart controls for MAD users. The designs were evidenced to respond to MAD users’ characteristics and support their active interactions with the controls in their execution of operational task-based commands (e.g. ‘push’) on behalf of their human partners. Furthermore, when evaluated using both usability and affective-based measures, the controls were evidenced to improve MADs’ overall UX; specifically their welfare (e.g. eliminating the need for them to jump to operate the controls - §7.2), level of usability (increasing the device’s ease, speed and accuracy of use – Chapter 7 and 8), level of experience (increasing their level of confidence and enjoyment while using the controls – Chapter 8), and bond with their human partners (Chapter 8).

Throughout the research, a practice of active ethical reflection was implemented, resulting in the development of an Ethical Toolkit for ACI Research (§9.2). The toolkit presents a series of ethical considerations which aim to help ACI practitioners understand their ethical roles and responsibilities throughout the research, and ultimately protect and ensure the wellbeing of the animal research participant.

As a result of the research activities conducted during this research, and with the aim to provide ACI practitioners with a clear, flexible, and conceptual roadmap to inform their planning and execution of an animal-centric design process, an Animal-Centred Design Framework (ACDF) (§9.3) was developed. It describes a series of 8 phases which, although in its current iteration are focused on the canine user, could arguably be applied to other animal users and research with different objectives than the ones presented here. Furthermore, in considering the ACDF’s call to researchers to seek the most up to date and comprehensive knowledge about the animal research participant as a species and as a user (§9.3.3), it advances the approach of designing for animals, by promoting the inclusion of biological, social, and design-based data into the human researchers’ understanding of the animal as a user and research participant.

10.3 Limitations

10.3.1. Limitation in the Participant Pool

Overall, although the importance of focusing on individual participants at this stage of the discipline’s development has been discussed in the text, the number of participants in this research was limited (ranging from 3 to 9). In part, this reflects the challenges of
conducting research with animal participants, especially when in their naturalistic settings, which requires a fair amount of planning and resources. Additionally, although I had the complete support of DFG during participant recruitment, assistance dogs are not an easy population to access. This is mostly due to the fact that, if engaged with during their training, their availability is limited or, if engaged with once deployed, there might be additional challenges to working with their disabled human partners, such as last-minute cancellations due to potential health related issues. Finally, the small participant cohort is also a result of the resources available to analyse the amount of data which can be produced by each participant within the scope of doctoral research.

Hence, the results of this research are not exhaustive and not necessarily generalisable; instead they should be regarded as initial approximations which will benefit from further investigation and replication to confirm and broaden their relevance.

10.3.2 Methodological Limitations

Due in part to the small participant cohort, as discussed above, some of the methodologies developed during the research have not been exhaustively validated; thus, their use should take into account the possibility that they might not apply to contexts other than that in which this research has taken place. Additionally, some of the methods applied were adapted from other disciplines to investigate specific questions within the research and there is a limit to the extent to which they could be adapted and successfully applied. For example, with regard to the MCPQ-R; as discussed in §6.1.4.4; the questionnaire was conceived as a tool for the assessment of dogs’ personality traits and temperament, rather than traits that might be more significant when investigating certain MAD interactions.

10.3.3 Working with Animal Users

The various challenges and limitations of working with animal users have been discussed in detail throughout the text; for example, the difficulty in accurately, clearly and explicitly interpreting MADs’ behaviours (§5.2.4.2), the adequate recording of MADs’ behaviours while interacting with technological devices (§6.2.7), and the challenges of in-home data collection (§8.5). However, it is important to acknowledge that, even though researchers are bound by our humanness and hence prevented from
experiencing what the animals we study experience, they can address these limitations by applying our analytical abilities towards interpreting animals’ behaviour in ways that lead to improvements in their UX. Doing so requires the vigilance for any nuanced behavioural cues the animals might manifest about their degree of consent, displeasure or pleasure, and preferences during the research activities they are involved in.

10.3.4 Design-related Limitations

As previously discussed in §7.2.5.3, the fidelity of the prototypes being tested seem to have significant influence on the behaviours observed. Hence, the limitations of prototyping when working with animal users should also be considered, as we cannot assume (as we might with humans) that they know they are interacting with an interim version instead of the final design; or that any changes to the design during its development are being understood as updates to an existing design. Furthermore, the prototype controls used did not offer study participants a design fully engineered to its expected degree of functionality; therefore, the technical difficulties (e.g. the push-pad getting stuck or the delay between the control being activated and the light turning on) should also be considered as limiting the research results.

10.4 Future Work

Overall, the contributions to knowledge of this research corroborate the importance of applying a UCD approach to the design of products and services for animal users, while revealing opportunities for future work that could investigate and improve the animal UX, including the following:

10.4.1 Replication of Methods with a Larger and More Diverse Participant Pool

As mentioned above, the research reported in this thesis remains limited by the small number of participants. Future research could aim to replicate the proposed methods and approaches with a larger participant pool of dogs, which might include other breeds of differing ages and backgrounds. Hence, expanding the applicability of the methods to dogs that present different physical, cognitive, and potentially sensory characteristics
and whose working or living environments might reveal other challenges not considered here and which might result in the methods’ evolution or adaptation.

10.4.2 Application of Methods to Other Interactions

Future research could also explore the application of the methods proposed in this thesis to other types of canine, or animal interactions. For example, this might include interactions whose outcomes do not necessarily relate to task work but to enrichment or entertainment (e.g. companion dogs) or which consider other animals’ challenges with their current interactions (e.g. livestock and their current living enclosures).

10.4.3 Prototyping for Animal Users

Future research could also focus on investigating the interactions between animal users and prototypes to increase our understanding of the implications (e.g. cognitive or sensory) interacting with an ‘unfinished’ product might have on the animal user and its impact on the assessment of their UX. Exploring, for example, the application of small batch manufacturing techniques which could offer a degree of fidelity and customization specific to individual or small groups of animal research participants.

10.4.4 The Role of Scent in Canine-centered Design

Based on scent being dogs’ most used sense to experience the world (§4.3.6.3), future work could explore the meaning of scent for dogs’ beyond those related to food; for example, scents that promote a change in state such as relaxation, focus, or a sense of safety (similar to the practice of aromatherapy in humans); scents that are known to be generally pleasant (e.g. flowers, fresh cut grass, freshly baked bread) or unpleasant (e.g. garbage, skunk or mildew) for humans and how they could be adapted to have similar meanings for dogs; or scents that might be used to orient or provide feedback for dogs’ use of technological devices (e.g. scent as a form of feedback as depicted in the freshlight concept §7.1.2.1). Doing so would increase our understanding of scent on the canine UX, and possibly unearth an approach to canine-centric design that is more akin to their characteristics as users.
10.4.5 The Advanced Training Stage (ATS)
Future research could further investigate the influence of the ATS in dogs’ ability to become MADs’, potentially developing training tools which could be adjusted to better respond to MADs learning styles and development as included in the How Might We statements presented in §5.2.2.4. Doing so could optimise MADs’ training window (§5.2.4.1), reduce the rate at which dogs are removed from the MAD program, and ultimately lead to an increase in MAD partnerships.

10.4.6 Advancing the Evaluation of the Animal UX
Just as there are expert evaluators in other disciplines (e.g. accessibility evaluators), future research could investigate how best to form ACI expert evaluators. At the same time, future research could also investigate the use of technology assisted observation of animal behavior as a means to more clearly and accurately inform the measurement and evaluation of the animal UX.

10.4.7 Inclusive Animal-centred Design
This last consideration concerns a goal that could only be achieved after other advancements in the field of ACI had taken place. However, because the aim of the discipline is to legitimize the animal as a user, future research could explore, similar approaches to those described by Luck in her paper Inclusive design and making in practice: Bringing bodily experience into closer contact with making (2018); whereby by advocating for “the expansion of inclusive design into a more material, inclusive designer-making movement, to acknowledge the universal problem of designing for everyone’s unique difference” innovative approaches to developing and designing custom products and experiences for animals could be developed.

10.5 Final Remarks
These past three years have been quite possibly the most rewarding and the most challenging experience in my personal and professional aim of improving animals’ wellbeing through design. They have taught me to think differently, reaching a specificity of thought and ability to articulate my arguments that I did not have before.
I will remain forever grateful to Clara, Rachael, the Open University and Dogs for Good – especially Duncan Edwards – for providing me with the resources, time, and guidance to educate and form myself as an animal centred designer. The process of designing for MADs has revealed the amount of assumptions that as a designer I have made during my practice of design, resulting in a newfound awareness which I believe has have made me a better designer for human and animal users alike. Furthermore, in carrying out the research, I have confirmed and reconfirmed the influence of the complex and context-dependent interplay that exists between the elements that make-up the UX. In doing so I have shaped a visual representation of the systemic nature of the UX, best described as a sort of spider web, whose nodes are composed of a mixture of heuristic, empirical, qualitative, and quantitative data. The nodes and their interconnections enable the triangulation of information as a means to consistently validate the research results while helping to keep our humanness as researchers in check. This leads me to conclude that research approaches that enable focussed and frequent – rather than deep and infrequent - data collection might be preferable at this early stage of ACI’s development as a discipline; because before being able to adequately study more complex interactions, understanding simpler ones will help define the fundamental building blocks needed for the legitimisation of animals as users.

Moreover, in relation to dogs, and MADs specifically, I think it important to acknowledge that in our role as their domesticators, we have purposely bred them to be driven by the need to please us. Doing so has made dogs highly amicable animals, which when viewed as a direct consequence of our influence and power over them would beg us to consider the implications these breeding practices might have on them as users and research participants. For example, in considering dogs’ ability to consent, on the one hand, the approaches regarding the acquisition of consent put forth by ACI researchers (§2.5) are of a very high standard; but, on the other hand, could it not be the case that MADs’ purpose-bred genetics would override what would possibly be their preference? Resulting in, for example, them choosing to please their handler in spite of having a day in which they would have preferred not to participate in the research? I don’t know the answer to these questions; however, by posing them I aim to highlight the depth of influence we have on animals and dogs specifically, and the
responsibility we have in considering not only the primary consequences of our actions, but secondary and tertiary ones as well.

Occasionally, during the course of the research, I experienced the reporting of animal behavior in a written format to be quite cumbersome in nature, making it hard to convey certain nuances of a situation which could possibly be best described using other forms of expression. For example, when reporting on MADs’ tail wagging behaviour in writing, the descriptions presented in this research remained quite broad (e.g. high, horizontal, low) and potentially open to interpretation. In order to report on MADs’ tail to a level of detail that resembles the actual observed state, other aspects, such as the tails’ shape, length, or girth should probably have been included; however, doing so would have required a significant amount of words and resources to do so. Conversely, reporting the same data based on an image or drawing of the dog’s tail that could then be visually analyzed would have provided what would seem a more faithful portrayal of the MADs’ actual behavior. Arguably, the level of analysis would depend on the number of aspects of the tail being considered; however, if for example, the analysis was automatically being carried out by a computer, these could be quite significant, allowing for visual data to be a truer representation of the dog’s observed tail wagging behavior. Hence, in as much as words serve us to structure and present our thoughts and arguments, when it comes to observing and reporting animal behavior, sometimes more visual formats might prove more accurate.

Lastly, I would like to share a personal reflection on how our approach to designing for animals could evolve. Let us consider the history of human-centred design, from its origins in home-made goods which were completely customized to the individual, to the establishment of the first craftspeople making artisanal goods for groups of people, to the advent of the first machinery and the production of larger quantities of goods, to the industrial revolution and mass-production of goods. Throughout this time, one could argue that, as our ability to produce goods increased, so did our knowledge and understanding of humans as users of goods; a claim partly supported by the development of fields such as human factors engineering, ergonomics and most recently ID. However, when it comes to animals, the design of goods for their use has had a very different history, one that seems to have mostly focused on mass production, while overlooking the activities related to the understanding of animal users. My intent
here is not to suggest that animal centred design should try to replicate the history of human centred design, but rather highlight the opportunity to use the tools we have available today, such as machine learning, virtual reality, or batch manufacturing, to investigate animals as users, on an individual, group, and species level so that the designs we create for them are informed not by a ‘one size fits all’ approach but rather by a ‘right size fits some’ approach.
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Appendix

1. MAD Partnership Study Consent Forms

Dog Smart Homes: Portable Controls Optimised for Mobility Assistance Dogs

Information and Consent Form

At any time you can decline to answer any questions or terminate any discussion.

At any time you can withdraw yourself and/or your dog from the study without justification.

No personal data relating to humans will be recorded in this research. Any recorded data will be anonymised and securely stored; it will be accessed only by the researcher(s) involved in the project and it will be protected by confidentiality according to The Open University’s privacy protection standards.

Before any research findings are published, we will share them with you to give you the opportunity to express any concerns you might have and to ensure that these are addressed to your satisfaction prior to publication.

Findings will always be published in anonymous form, unless you request otherwise (e.g. if you agree to co-author related publications). Photo, video or audio recordings will only be published with your explicit permission.

This research is conducted with the approval of The Open University’s Animal Welfare Ethical Review Body and will fully comply with the Animal-Computer Interaction (ACI) Research Ethics Protocol provided to you together with this consent form.

If you are satisfied with the information provided here, and if you are happy to participate in this research and, as their legal guardian, are happy for your dog/s to participate with you, please complete below:

☑️ I have read and understood the information regarding the project entitled “Dog-Smart Homes: Portable Controls Optimised for Mobility Assistance Dogs”.

☐ I agree to partake in the research together with the assistance dogs in training at the facility of Dogs for Good, National Training Centre in Banbury, UK, or with the assistance dogs I have been partnered with by Dogs for Good.

☐ I agree to myself and the dogs participating in the research under my responsibility to be recorded for the purposes of the project.

Date  Printed Name  Signature

__________________________________  ______________________________________  ____________________________
Information and Consent Form

Thank you for expressing an interest in this research project, which is part of a wider research program on Animal-Computer Interaction currently being developed at The Open University’s Centre for Research in Computing (http://crc.open.ac.uk/Themes/ACI).

My name is Elizabeth Cox and I am a research fellow as part of Luísa Ruge’s 3-year PhD project: Dog-Smart Homes: Portable Controls Optimised for Mobility Assistance Dogs. Our supervisors are Dr Clara Mancini, Senior Lecturer in Interaction Design and the head of the Animal-Computer Interaction Lab at the Open University’s Department of Computing and Communications, and Dr Rachael Luck, Senior Lecturer and Director of Research for the School of Engineering and Innovation, Deputy Editor for the journal Design Studies, Tutor on the IDBE Interdisciplinary Design of the Built Environment course at Cambridge University.

In this research we will be investigating the process of dogs becoming mobility assistance aids, the placement and partnerships created and the aftercare of the duos, as a means to identify how we can design appropriate controls for canine use.

The research is set to last 3 years during which we will be in continuous interaction with Dogs for Good as our research partners.

The objective of the research will vary depending on the stage of the project, however main research goals by phase are outlined below:

Phase 1 Discover: Insight into the Problem
Gaining an in-depth understanding of the complete process and context that mobility assistance dogs, their human handlers and all stakeholders go through during the breeding, socializing, training, placement and retirement of the dogs.

Phase 2 Define: The Area to Focus On
Understand the needs for all stakeholders involved in order to identify potential design interventions and a means to improve duo performance and wellbeing. Define canine interaction design principles to guide design.

Phase 3 Develop: Potential Solutions
Establish a canine centered design framework to enable the design and production of possible solutions. Establishing an evaluative process to identify which solutions to further develop based on stakeholder and contextual requirements.

Phase 4 Deliver: Solutions that Work
Evaluate and refine final design solutions within their normal use contexts.

In order to achieve these objectives, we will be carrying out a variety of research activities. These will vary according to the type of information needed. However no activity will be done without first obtaining your permission and consent in a manner that is comfortable for you, appropriate for the welfare of the dogs and does not interfere with your activities.

During the activity I will be recording the session, using the method that is preferable to you. Please tick your preferred recording method (if there are any changes to your preference please let me know before starting any activity):

- [ ] Handwritten notes
- [ ] Audio recording
- [ ] Photographic recording
- [ ] Video recording
2. HREC/2016/2303/Mancini/1

Human Research Ethics Committee (HREC)

From
Duncan Banks, Deputy Chair
The Open University Human Research Ethics Committee
Email duncan.banks@open.ac.uk
Extension (6) 59198

To
Clara Mancini, Department of Computing and Communications, STEM

Project title
Dog-Smart Homes: Canine Interfaces for Mobility Assistance Dogs.
HREC ref
HREC/2016/2303/Mancini/1
AMS ref
n/a

Date application submitted: 19/05/16
Date of HREC response: 26/05/16

Memorandum

This memorandum is to confirm that the research protocol for the above-named research project, as submitted to the OU HREC for ethics review, has been given a favourable opinion by Chair’s action.

Please note the following:

1. You are responsible for notifying the HREC immediately of any information received by you, or of which you become aware which would cast doubt on, or alter, any information contained in the original application, or a later amendment which would raise questions about the safety and/or continued conduct of the research.

2. It is essential that any proposed amendments to the research are sent to the HREC for review, so they can be recorded and a favourable opinion given prior to any changes being implemented (except only in cases of emergency when the welfare of the participant or researcher is or may be effected).

3. You are authorised to present this memorandum to outside bodies such as NHS Research Ethics Committees in support of any application for future research clearance. Also, where there is an external ethics review, a copy of the application and outcome should be sent to the HREC.

4. OU research ethics review procedures are fully compliant with the majority of grant awarding bodies and where they exist, their frameworks for research ethics.

5. At the conclusion of your project, by the date you have stated in your application, you are required to provide the Committee with a final report to reflect how the project has progressed, and importantly whether any ethics issues arose and how they were dealt with. A copy of the final report template can be found on the research ethics website - http://www.open.ac.uk/research/ethics/human-research-human-research-ethics-full-review-process-and-proforma#final_report

Best regards,

Dr Duncan Banks, Deputy Chair
The Open University Human Research Ethics Committee
http://www.open.ac.uk/research/ethics/

www.open.ac.uk/research/ethics/ January 2015
3. HREC/2018/3080/Ruge

Dear Luisa,

This message confirms that the research protocol for the following research project, as submitted for ethics review, has been given a favourable opinion on behalf of The Open University Human Research Ethics Committee.

Project title: Designing for the Canine User Experience: Improving Mobility Assistance Dog Working Environments

HREC approval date: 22/11/2018

As part of your favourable opinion, it is essential that you are aware of and comply with the following:

1. You are responsible for notifying the HREC immediately of any information received by you, or of which you become aware which would cast doubt on, or alter, information in your original application, in order to ensure your continued safety and the good conduct of the research.

2. It is essential that you contact the HREC with any proposed amendments to your research, for example - a change in location or participants. HREC agreement needs to be in place before any changes are implemented, except only in cases of emergency when the welfare of the participant or researcher is or may be affected.

3. Your HREC reference number has to be included in any publicity or correspondence related to your research, e.g. when seeking participants or advertising your research, so it is clear that it has been agreed by the HREC and adheres to OU ethics review processes.

4. Researchers should have discussed any project-related risks with their Line Manager and/or Supervisor, to ensure that all the relevant checks have been made and permissions are in place, prior to a project commencing, for example compliance with IT security and Data protection regulations.

5. Researchers need to have read and adhere to relevant OU policies and guidance, in particular the Ethics Principles for Research involving Human Participants and the Code of Practice for Research - http://www.open.ac.uk/researchethics/

6. The Open University’s research ethics review procedures are fully compliant with the majority of research council, professional organisations and grant awarding bodies research ethics guidelines. Where required, this message is evidence of OU HREC support and can be included in an external research ethics review application. The HREC should be sent a copy of any external applications, and their outcome, so we have a full ethics review record.

7. At the end of your project you are required to assess your research for ethics related issues and/or any major changes. Where these have occurred you will need to provide the Committee with a HREC final report to reflect how these were dealt with using the template on the research ethics website - http://www.open.ac.uk/researchethics/human-research/full-review-process

(HREC Final Report form)

Sent on behalf of the Human Research Ethics Committee
Professor Louise Westmarland Dr Duncan Banks Dr Claire Hewson
Chair Deputy Chair Deputy Chair

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Human Research Ethics Committee
The Open University
Walton Hall, Milton Keynes, MK7 6AA
http://www.open.ac.uk/researchethics/human-research
4. The MAD User Journey - Participant Consent Forms and Interview Guide

December 4-8 / Dogs for Good
Consent Form
Dog Smart Homes: Portable Controls Optimised for Mobility Assistance Dogs

Thank you very much for taking the time to sit down with me, I know things here are always busy and hectic. I would like for you to see this as a chance to have a candid and informal conversation. This is not an exercise with any evaluative intent, it is a way to understand the needs, goals and desires of DFG as a way to plan a research strategy for the design of the portable controls.

I will be asking questions about the following topics:
• Your background
• Your experience at DFG
• How you see MADs process and journey in its current state
• How would you improve the overall process and as it pertains to the partnership?

If at any point during the conversation you feel the question makes you uncomfortable or you do not want to answer please let me know and we will quickly move onto the next question without any issues.
You can choose to opt out now, or at any time during the duration of the exercise.

Please indicate your preferred method of data collection:

__ audio recording    __ video recording    __ handwritten notes    __ none

If you consent to participate please sign and date here:

_____________________________________________________________

Thank you!
Background
Tell me a bit about yourself......
What/where did you work at previously?
How did you arrive at DFG, and why did you decide to join?
How long have you been at DFG?
What do you like most about your role and why?
What do you like the least about your role and why?
How would you classify your overall experience to date at DFG?

Experience at DFG
What are the current activities you are involved in?
How do these activities tie into the rest of the process?
Who/what do you depend on to carry out the activities?
Who/what depends on you to carry out their activities?

Current Process
How would you describe the current process of graduating and placing a mobility assistance dog?
What are the phases you feel are the most difficult and why?
What are the phases you feel are the most rewarding and why?
What is your favourite phase(s) and why?
What is your least favourite phase(s) and why?
What are the biggest factors that are affecting the current process? Why?
What are the biggest factors that you feel affect human performance and wellbeing? Why?
What are the biggest factors that you feel affect canine performance and wellbeing? Why?
What are the biggest factors that you feel affect partnership performance and wellbeing? Why?

Process Improvement
Are there any changes you feel could immediately improve the process? Why?
if left to your own devices what would you change and why?
How would you go about understanding what changes would have the most impact on the process?

Partnership Focus
Are there any changes you feel could immediately improve the process? Why?
if left to your own devices what would you change and why?
How would you go about understanding what changes would have the most impact on the process?

Is there anything I have missed you would like to add?
5. The MAD User Journey – Data Analysis Code List

Initial and emergent (bolded) code list for interview data analysis

<table>
<thead>
<tr>
<th>Code</th>
<th>Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BO</td>
<td>MAD – trainer bond</td>
</tr>
<tr>
<td>C</td>
<td>Other commands</td>
</tr>
<tr>
<td>CT</td>
<td>Client training</td>
</tr>
<tr>
<td>DA</td>
<td>MAD related data analysis</td>
</tr>
<tr>
<td>DC</td>
<td>MAD related data collection</td>
</tr>
<tr>
<td>DT</td>
<td>MADs development during training</td>
</tr>
<tr>
<td>EVA</td>
<td>Assessments and evaluations</td>
</tr>
<tr>
<td>M</td>
<td>Matching process</td>
</tr>
<tr>
<td>MADD</td>
<td>Data collected about dogs in training</td>
</tr>
<tr>
<td>MADPOV</td>
<td>Interpretation of the MAD experience</td>
</tr>
<tr>
<td>O</td>
<td>Other content</td>
</tr>
<tr>
<td>OC</td>
<td>Operational commands</td>
</tr>
<tr>
<td>PP</td>
<td>Predicting MAD performance during training</td>
</tr>
<tr>
<td>R</td>
<td>MAD – trainer relationship</td>
</tr>
<tr>
<td>ST</td>
<td>Accounts of training successes</td>
</tr>
<tr>
<td>T</td>
<td>Training process</td>
</tr>
<tr>
<td>TA</td>
<td>Artefacts, tools used during training</td>
</tr>
<tr>
<td>TC</td>
<td>Training challenges</td>
</tr>
<tr>
<td>TCI</td>
<td>Cognitive impact of training on MADs</td>
</tr>
<tr>
<td>TD</td>
<td>Training Data</td>
</tr>
<tr>
<td>TDFG</td>
<td>Training at DFG</td>
</tr>
<tr>
<td>TE</td>
<td>Training environments</td>
</tr>
<tr>
<td>TEX</td>
<td>Trainer experience</td>
</tr>
<tr>
<td>TPER</td>
<td>Impact on performance due to training on MADs</td>
</tr>
<tr>
<td>TPI</td>
<td>Physical impact of training on MADs</td>
</tr>
<tr>
<td>TSI</td>
<td>Sensory impact of training on MADs</td>
</tr>
<tr>
<td>TT</td>
<td>Timing of training</td>
</tr>
<tr>
<td>TWEL</td>
<td>Impact on wellbeing due to training on MADs</td>
</tr>
<tr>
<td>W</td>
<td>MAD withdrawal</td>
</tr>
</tbody>
</table>
6. The Advanced Training Stage - Participant Consent Forms and Interview Guides

The Advanced Training Stage / March 19-23 / Dogs for Good
Interview Consent Form

Introduction
As a means of introduction my name is Elizabeth Cox and I am here as a research fellow for the project. My background is in veterinary nursing and I have a Masters in Animal Behaviour and Welfare. I am interested in this project because I hope that in time, our human world can be made more accessible for assistance dogs so that they can better support the humans they are paired with. I would like to start by thanking you for taking the time to sit down with me, I know things here are always busy and hectic.
The interview as such is more in the format of a candid and informal conversation, where there are no right or wrong answers because it is not an exercise with any evaluative intent, and because I am not the expert, you are. Its intention is to understand the activities, types of interactions and methods used for task training.
If at any point during the interview I ask a question that makes you uncomfortable in any way, you can decline to answer or terminate any discussion. In addition, at any time you can withdraw yourself and/or your dog from the study without justification. No personal data relating to humans will be recorded in this research. Any recorded data will be anonymised and securely stored; it will be accessed only by the researcher(s) involved in the project and it will be protected by confidentiality according to The Open University’s privacy protection standards. You can choose to opt out now, or at any time during the duration of the exercise.

We will be covering the following areas:
1. Basic Information
2. Your experience as a trainer at DFG
3. Training protocols, with specific focus on task training
4. Training exercises, with specific focus on task training with regards to what the exercise entails, tools used, and environments trained and tested in
5. Your experience with watching dogs develop through the training in terms of their wellbeing and performance
6. Your experience with the bond created throughout the training process
7. Your experience when training with clients
8. Photo journal exercise

Finally, if at any time I glance down at the page it’s just to make sure I have covered all the questions we wanted to ask.
Please indicate your preferred method of data collection:

__ audio recording __ video recording __ handwritten notes __ none

If you consent to participate please sign and date here:

__________________________

Thank you
Basic Information
Tell me a little about yourself, I know you covered this in December, but I would appreciate a re-cap. (Only with Mel and Leanne)
Name:
Role at DFG:
Past Training Experience:
Years at DFG:

Your experience as a trainer at DFG
1. What do you think DFG looks for in a trainer?
2. What training did you receive when you started at DFG?
3. Since then have there been any changes to the training protocols?
   (If yes why and when, who made the changes, who implemented them?)
   • If there were changes how do you think they impacted your role?
   • How would you rate the changes, why?
4. How many dogs are you currently training?
5. Tell me about your dogs: name, breed, age, training week, temperament current)
Is there anything else you would like to add about your experience as a trainer at DFG that I did not ask?

2. Training protocols, with specific focus on task training
1. Could you describe the 16-week training process by week, the types of training and protocols used?
   • Do you group the training weeks in any other way? For example: tasks that require more time in public spaces vs facility, easier or harder for the dogs? If so why?
2. How many total commands do you train?
3. Out of those how many are task related and what are they?
4. Are there task commands that are harder to train?
5. If yes why, and how do you overcome this?
6. Are there any patterns in training the “hard commands” (For example: are they common across dogs or are they particular to every dog?)
Is there anything else you would like to add about the training protocols that I did not ask?

3. Training exercises, with specific focus on task training with regards to what the exercise entails, tools used, and environments trained and tested in
   For each command mentioned above:
   1. How are they trained in terms of time?
   2. How are they trained in terms of tools?
   3. How are they trained in terms of training environments?
      • Are there any other elements that determine the way they are trained?
   4. What are the main struggles related to this command? Why do you think this is?
      • What are areas that are easy related to this command? Why do you think this is?
   5. Do any training patterns emerge for this command? For example: breeds vs command
   6. Could this command be trained in a canine friendly way?
   7. Based on this, how canine friendly are the current training methods?
• Could this command be trained differently in terms of time?
8. Could this command be trained differently with regards to tools?
• Could this command be trained differently with regards to training environment?
9. Does the training of this command address/impact the dog’s physical capabilities?
• Does this vary by dogs? If yes why?
10. Does the training of this command address/impact the dog’s cognitive capabilities?
• Does this vary by dogs? If yes why?
11. Does the training of this command address/impact canine sensory capabilities?
• Does this vary by dogs? If yes why?
12. How is this command tested?
• Does it get tested more than once? If yes what are the differences between the tests?
13. Do you track any data specific to the training and testing of the command? If yes how and what is captured?
14. By who and when is it analysed, what is done with the results?
• Have you identified any testing patterns of your own? If yes which ones and why?
Is there anything else you would like to add about the training and testing exercises that I did not ask?

4. Your experience with watching dogs develop through the training in terms of their wellbeing and performance
1. What information do you have about the dog when they come in for training?
• Do you come back to this information at any point in time during the training? If yes why?
2. What information is gathered during the training, and how is it used?
3. Are there areas that you see changes in the dog during the training that are not covered in the existing information gathering? If yes which ones are they?
• If yes, would you see any value in capturing this type of information?
4. How do you track the dog’s development throughout the training?
• Are you able to predict how a particular dog will develop throughout training? If yes how?
5. Are there any points during the training where you can clearly identify any impact on the dogs in terms of their wellbeing and/or performance? If yes when and why?
Is there anything else you would like to add about the experience of watching dogs develop through the training in terms of their wellbeing and/or performance that I did not ask?

5. Your experience with the bond created throughout the training process
1. How would you describe your relationship with the dogs you train?
• What makes this relationship vary? For example, dog breed, age of dog?
2. Does the relationship change during training? If yes, how?
• What do you like about the relationship?
• What do you struggle with about the relationship?
3. In your opinion, how would the dogs being trained describe the relationship? For example, with a current dog you are training
4. What is the value of the relationship during the training process?
5. How does the relationship impact training? (Are training exercises, tools or environments impacted by the training?)
Is there anything else you would like to add about the experience with the bond created throughout the training process that I did not ask?

6. Your experience when training with clients
1. Do you train with clients? If yes when does this usually happen?
• What is the major difference between training on your own and training with clients in terms of the exercises? Why?
2. What are the major difference between training on your own and training with clients in terms of the training tools used? Why?
• What is the major difference between training on your own and training with clients in terms of the environments? Why?
• In your opinion, what are the major differences for the dogs between training activities with you and with clients?
3. In your opinion, what are the major differences for the dogs between training tools with you and with clients?
• In your opinion, what are the major differences for the dogs between training with you in various environments and with clients?
Is there anything else you would like to add about the experience of training with clients that I did not ask?

Do you have any more questions/concerns/comments?
7. Code List

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDFG</td>
<td>Training at DFG</td>
</tr>
<tr>
<td>CD</td>
<td>Canine Data/Dogs currently in training</td>
</tr>
<tr>
<td>TPR</td>
<td>Training process</td>
</tr>
<tr>
<td>OC</td>
<td>Other Commands</td>
</tr>
<tr>
<td>TC</td>
<td>Task Commands</td>
</tr>
<tr>
<td>TIP</td>
<td>Timing of training</td>
</tr>
<tr>
<td>TTT</td>
<td>Training tools</td>
</tr>
<tr>
<td>TTE</td>
<td>Training environments</td>
</tr>
<tr>
<td>TTS</td>
<td>Training struggles</td>
</tr>
<tr>
<td>TTP</td>
<td>Training patterns</td>
</tr>
<tr>
<td>TTCI</td>
<td>Training cognitive impact</td>
</tr>
<tr>
<td>TTPi</td>
<td>Training physical impact</td>
</tr>
<tr>
<td>TTSI</td>
<td>Training sensory impact</td>
</tr>
<tr>
<td>TTRI</td>
<td>Training performance impact</td>
</tr>
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<td>TTWI</td>
<td>Training wellbeing impact</td>
</tr>
<tr>
<td>TS</td>
<td>Training success</td>
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<tr>
<td>AS</td>
<td>Assessments</td>
</tr>
<tr>
<td>DA</td>
<td>Data analysis</td>
</tr>
<tr>
<td>DGT</td>
<td>Data gathering during training</td>
</tr>
<tr>
<td>TTD</td>
<td>Training development</td>
</tr>
<tr>
<td>PCP</td>
<td>Predicting dog performance in training process</td>
</tr>
<tr>
<td>CPOV</td>
<td>From the dogs' point of view</td>
</tr>
<tr>
<td>CTR</td>
<td>Canine-trainer relationship</td>
</tr>
<tr>
<td>CT</td>
<td>Client training</td>
</tr>
<tr>
<td>CTD</td>
<td>Client training differences for canines</td>
</tr>
<tr>
<td>O</td>
<td>Other content</td>
</tr>
<tr>
<td>RI</td>
<td>Research Impact</td>
</tr>
<tr>
<td>M</td>
<td>Matching</td>
</tr>
<tr>
<td>W</td>
<td>Withdrawal</td>
</tr>
</tbody>
</table>
8. Code List for MADs’ and Their Trainers’ Behaviour at a 1:1 and 1:2 Playback Speed

<table>
<thead>
<tr>
<th>Codes for 1:1 Playback Speed</th>
<th>Codes for 1:2 Playback Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>Description</td>
</tr>
<tr>
<td>1   TIC</td>
<td>Trainer issues command</td>
</tr>
<tr>
<td>2   TPC</td>
<td>Trainer points towards control</td>
</tr>
<tr>
<td>3   TLC</td>
<td>Trainer leans towards control</td>
</tr>
<tr>
<td>4   DA</td>
<td>MAD approaches control</td>
</tr>
<tr>
<td>5   DP</td>
<td>MAD uses paw to activate control</td>
</tr>
<tr>
<td>6   DSN</td>
<td>MAD uses snout to activate control</td>
</tr>
<tr>
<td>7   DSIT</td>
<td>MAD sits</td>
</tr>
<tr>
<td>8   DLAY</td>
<td>MAD lays down</td>
</tr>
<tr>
<td>9   DJ</td>
<td>MAD jumps</td>
</tr>
<tr>
<td>10  TGR</td>
<td>Trainer gives reward</td>
</tr>
<tr>
<td>11  DO</td>
<td>Door opens</td>
</tr>
<tr>
<td>12  DLT</td>
<td>MAD looks towards trainer</td>
</tr>
<tr>
<td>13  DLC</td>
<td>MAD looks towards control</td>
</tr>
<tr>
<td>14  DLD</td>
<td>MAD looks towards door</td>
</tr>
<tr>
<td>15  DLTB</td>
<td>MAD looks towards treat bag</td>
</tr>
<tr>
<td>16  DLTH</td>
<td>MAD looks towards trainer’s hands</td>
</tr>
<tr>
<td>17  DLA</td>
<td>MAD looks away from the door and trainer</td>
</tr>
<tr>
<td>18  DRP</td>
<td>MAD uses right paw to activate control</td>
</tr>
<tr>
<td>19  DLP</td>
<td>MAD uses left paw to activate control</td>
</tr>
<tr>
<td>20  DNC</td>
<td>MAD approaches control but does not make contact</td>
</tr>
<tr>
<td>21  DWT</td>
<td>MAD wags tail</td>
</tr>
<tr>
<td>22  DTT</td>
<td>MAD tucks tail</td>
</tr>
<tr>
<td>23  DMEF</td>
<td>MAD moves ears forward</td>
</tr>
<tr>
<td>24  DMEB</td>
<td>MAD moves ears back</td>
</tr>
<tr>
<td>25  DCW</td>
<td>MAD comes into contact with the wheelchair</td>
</tr>
<tr>
<td>26  DSA</td>
<td>MAD sniffs air</td>
</tr>
<tr>
<td>27  DSF</td>
<td>MAD sniffs floor</td>
</tr>
<tr>
<td>28  DS</td>
<td>MAD shakes</td>
</tr>
<tr>
<td>29  TMCS</td>
<td>Trainer moves towards control</td>
</tr>
<tr>
<td>30  TMW</td>
<td>Trainer moves wheelchair</td>
</tr>
<tr>
<td>31  ODB</td>
<td>Other MAD behavior</td>
</tr>
<tr>
<td>32  DLL</td>
<td>MAD licks lips</td>
</tr>
<tr>
<td>33  OTB</td>
<td>Other trainer behavior</td>
</tr>
<tr>
<td>34  TDA</td>
<td>Trainer gets dog’s attention</td>
</tr>
<tr>
<td>35  TINC</td>
<td>Trainer issues “nudge” command</td>
</tr>
<tr>
<td>36  TIPC</td>
<td>Trainer issued “push” command</td>
</tr>
<tr>
<td>37  DDO</td>
<td>Door does not open</td>
</tr>
<tr>
<td>38  TGVR</td>
<td>Trainer gives verbal reward</td>
</tr>
<tr>
<td>39  TGRF</td>
<td>Trainer gives food reward on floor</td>
</tr>
<tr>
<td>40  TGRH</td>
<td>Trainer gives food reward in hand</td>
</tr>
<tr>
<td>41  GTD</td>
<td>Trainer and MAD go through door</td>
</tr>
<tr>
<td>42  RA</td>
<td>Researcher appears in video</td>
</tr>
</tbody>
</table>
## 9. Code List Formatted According to the Likelihood of the Code Being Applied to a Subtask

Start, attempt, and reward of the main task sequence during the investigations of MADs affect-based interactions.

<table>
<thead>
<tr>
<th>Task</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>Attempt</td>
<td>Reward</td>
</tr>
<tr>
<td>DSIT</td>
<td>MAD sits</td>
<td></td>
</tr>
<tr>
<td>DLAY</td>
<td>MAD lays down</td>
<td></td>
</tr>
<tr>
<td>DWT</td>
<td>MAD wags tail</td>
<td></td>
</tr>
<tr>
<td>ODB</td>
<td>Other MAD behavior</td>
<td></td>
</tr>
<tr>
<td>DS</td>
<td>MAD shakes</td>
<td></td>
</tr>
<tr>
<td>DLT</td>
<td>MAD looks towards trainer</td>
<td></td>
</tr>
<tr>
<td>DLC</td>
<td>MAD looks towards control</td>
<td></td>
</tr>
<tr>
<td>DLA</td>
<td>MAD looks away from the door and trainer</td>
<td></td>
</tr>
<tr>
<td>OTB</td>
<td>Another trainer behavior</td>
<td></td>
</tr>
<tr>
<td>TOA</td>
<td>Trainer gets dog’s attention</td>
<td></td>
</tr>
<tr>
<td>TMW</td>
<td>Trainer moves wheelchair</td>
<td></td>
</tr>
<tr>
<td>DP</td>
<td>MAD uses paw to activate control</td>
<td></td>
</tr>
<tr>
<td>DSN</td>
<td>MAD uses snout to activate control</td>
<td></td>
</tr>
<tr>
<td>DA</td>
<td>MAD approaches control</td>
<td></td>
</tr>
<tr>
<td>DJ</td>
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<td></td>
</tr>
<tr>
<td>DNC</td>
<td>MAD approaches control but does not make contact</td>
<td></td>
</tr>
<tr>
<td>TINC</td>
<td>Trainer issues “nudge” command</td>
<td></td>
</tr>
<tr>
<td>TIPC</td>
<td>Trainer issued “push” command</td>
<td></td>
</tr>
<tr>
<td>Tic</td>
<td>Trainer issues command</td>
<td></td>
</tr>
<tr>
<td>TPC</td>
<td>Trainer points towards control</td>
<td></td>
</tr>
<tr>
<td>TLC</td>
<td>Trainer leans towards control</td>
<td></td>
</tr>
<tr>
<td>TGR</td>
<td>Trainer gives reward</td>
<td></td>
</tr>
<tr>
<td>DDO</td>
<td>Door does not open</td>
<td></td>
</tr>
<tr>
<td>DO</td>
<td>Door opens</td>
<td></td>
</tr>
<tr>
<td>TGVR</td>
<td>Trainer gives verbal reward</td>
<td></td>
</tr>
</tbody>
</table>
10. Refined Design Concepts

IBUMP

COMMAND: "Nudge"
INSTALL: Short Height/Wall
FEEDBACK: Treat
ACTIVATION: Pressure

2BOINK

COMMAND: "Nudge"
INSTALL: Plug In
FEEDBACK: Activation / Noise
ACTIVATION: Pressure
3STRIP

Command: "Nudge"
Install: Wall Mounted
Feedback: Light
Activation: Pressure

4BARK

Command: "name of task"
Install: Speaker on "Appliance"
Feedback: Activation
Activation: Bark | Noise

1. "Light"
2. "Bark"
3. Light
4. Other appliances
**SUP & DOWN**

COMMAND: "name of task" / "poop"
INSTALL: floor/bed to task
FEEDBACK: treat pop
ACTIVATION: pressure

**RESET**

COMMAND: "on" / "off"/"fetch"
INSTALL: free roaming
FEEDBACK: "click"
ACTIVATION: pressure
**ICON**

**COMMAND:** Retrieve

**INSTALL:** On floor

**FEEDBACK:** Color, painting, sound

**ACTIVATION:** Pressure

---

**CARROT**

**COMMAND:** Fetch

**INSTALL:** Wall mount, free

**FEEDBACK:** Treat

**ACTIVATION:** Pressure

---

L. Rana 25.08.19
**319**

**9SHIN**
- **COMMAND:** "nudge"
- **INSTALL:** wearable
- **FEEDBACK:** human
- **ACTIVATION:** pressure

**IOREMOTE**
- **COMMAND:** task
- **INSTALL:** free-floating
- **FEEDBACK:** human praise
- **ACTIVATION:** human pressure

![Diagram of 9SHIN](image1)
![Diagram of IOREMOTE](image2)
COMMAND: "fetch"
INSTALL: free-floating
FEEDBACK: human treats
ACTIVATION: pressure/heat
Skin opens

1. Night
2. Elephant
3. Human activation
4. Treat slot
Unsealable heat dispenser
11. 2019 Edinburgh International Science Fair

The Edinburgh International Science Fair is a yearly event founded and funded by the Edinburgh Science Foundation an educational charity, founded in 1989. The Open University booth was part of the 2019 Festival held from Saturday 6 – Sunday 21 April, specifically the Careers Hive programme which was held at the National Museum of Scotland and welcomed nearly 3000 students. In collaboration with Dogs for Good and Medical Detection Dogs we showcased the work carried out to date as part of the larger project this research is part of: Dogs with Important Jobs.
## 12. Concept Evaluation Matrix

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<tbody>
<tr>
<td>Respond to their physical characteristics in a way that:</td>
<td>3 3 3 2 3 2 2 3 3 2 2 1 3 3 3 3</td>
<td>2 1 3 3 3 3 3 2 3 2 3 3 3 3 2 3</td>
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<td>If intended to be activated by the use of their snout are installed at heights between 55-80cm.</td>
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<td>Have an appropriate degree of sensitivity of their operational parts based on their mode of interaction.</td>
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<td>In order to activate, do not require them to jump or exert any unnecessary strain on their joints.</td>
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<td>3 3 3 3 3 3 3 2 3 3 3 3 3 3 2 3</td>
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<td>Have operational parts robust enough to withstand the forceful interactions MADS are likely to exert.</td>
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<td>Respond to their cognitive characteristics in a way that:</td>
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<td>3 3 2 2 2 2 2 3 2 2 2 1 2 2 1 2 1</td>
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<td>Clear feedback in response to their interactions with them.</td>
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<td>2 2 3 2 2 3 2 3 3 2 2 2 1 2 3 3 2</td>
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<td>Information as to how to interact with them with little to no need for human help or support.</td>
<td>3 3 2 2 2 2 2 3 2 2 2 1 2 2 1 2 1</td>
<td>2 2 3 2 2 3 2 3 3 2 2 2 1 2 3 3 2</td>
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<td>Their features help reduce the amount of time required for MADS to reach fluency of use.</td>
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<td>3 3 2 2 2 2 3 2 3 3 2 2 1 2 3 3 2</td>
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<td>Their design and features support humans’ accurate, clear, and explicit understanding of the quality of MADS interactions with them.</td>
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<td>2 2 3 2 2 3 2 3 3 2 2 2 1 2 3 3 2</td>
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<td>Their design and features support the consistency with which any food-based rewards are delivered.</td>
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<td>1 1 3 2 2 3 3 3 2 3 2 2 3 2 2 2</td>
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<td>Their design and features can be adapted to respond to MADS individual capabilities.</td>
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<td>1 1 2 3 2 2 3 2 2 2 2 2 2 2 2 3 2 3</td>
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<td>Respond to their sensory characteristics in a way that:</td>
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<td>3 3 2 2 3 3 2 3 2 3 2 2 3 3 2 3 3 2</td>
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<td>Overall shape and features are perceivable even when blurry.</td>
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<td>2 2 3 3 2 3 2 3 3 2 3 2 3 3 2 3 3 2</td>
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<td>Sound emissions are detectable by MADS, and if possible provide them with a clear meaning related to their function.</td>
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<td>3 2 3 3 3 3 3 2 2 3 2 3 3 2 3 3 2 3</td>
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<td>Contrast within the environments they are installed in.</td>
<td>3 2 3 3 3 3 3 2 2 3 2 3 3 2 3 3 2 3</td>
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**FINAL RANK**
13. MAD Partnership Initial In-home Interview

Introduction
Thank you so much for wanting to participate in this research, your opinion is incredibly valuable, and we truly thank you for your time and your willingness to invite us into your home. This interview as such is in the format of a candid and informal conversation, where there are no right or wrong answers because it is not an exercise with any evaluative intent, and because I am not the expert, you are. Its intention is to understand the activities, types of interactions and methods that you, as a recipient of a mobility assistance dog use for task training. If at any point during the interview I ask a question that makes you uncomfortable in any way, you can decline to answer or terminate any discussion. In addition, at any time you can withdraw yourself and/or your dog from the study without justification. Recorded data will be anonymised and securely stored; it will be accessed only by the researcher(s) involved in the project and it will be protected by confidentiality according to The Open University’s privacy protection standards, and the consent form you filled out.

Overview
1. General information about you and your dog
2. Training activities, with specific focus on task training
3. Your experience with watching dogs develop through placement to now in terms of their wellbeing and performance
4. Your experience with the bond created between you and your dog from placement to now
Finally, if at any time I glance down at the page it’s just to make sure I have covered all the questions we wanted to ask. Do you have any more questions/concerns/comments before we begin?

General Info
What is your name and how do you prefer to be addressed?
What is your dog’s name, breed and age?
How long have you had her/him?
Is this your first MAD?
If not, when/who was your last one?
Why did you first want a MAD?
What were your expectations of having a MAD?
Has this expectation been met? If not, why?
Have there been other unexpected/surprising outcomes?
How would you describe the impact of having a MAD has had in your life?
Is there anything else you would like to add as general information?
**Task Training Activities**

Do you remember your first impression when you met (dog’s name)?
How would you describe, to the best of your ability your first week?
What would you say took the most adjustment in having a dog (if their first), or this particular dog (if their second)?
What would you say took the least adjustment in having a dog (if their first), or this particular dog (if their second)?
How was DFG staff involved during this process?
How much training adjustment has (dogs name) had since placement?
Why do you think this is?
What kinds of tasks does (dogs name) perform for you?
Of these tasks which ones did not change from when the dog was placed?
Which tasks did (dogs name) have to learn after placement?
How were they trained?
What would you say are the tasks the dog provides you with the most assistance with?
Which if these have the most value for you? Why?

**Training Commands**

For each command mentioned above that requires the dog to interact with a control panel/interface/product:
When were they trained?
If trained in the home, how much time did it take?
Are there any struggles related to this task?
Why do you think this is?
If yes, how have you overcome them?
If no, how would you improve the process?
Did you help in training this task?
Would you change anything about the process/your involvement in training this task?
If any DFG employees where part of this process, how would you describe their role?
Can you think of a way that would improve this task for you?
Can you think of any way that the task could be improved from the dog’s point of view (time, tools, environments)?
How do you think this task addresses/impacts the dog’s physical capabilities?
How do you think this command addresses/impacts the dog’s cognitive capabilities?
How do you think this command addresses/impacts canine sensory capabilities?
Is there anything else you would like to add about the training activities that I did not ask?
MAD Development
How would you describe the development of (dogs name) from placement to now?
How would you describe the behaviour of (dogs name) from placement to now?
How have you experienced the emotional state of (dogs name) from placement to now?
How would you describe the performance and wellbeing of (dogs name) from placement to now?
Is there any command that has a clear impact (negative and positive) on (dogs name)?
Are there any situations that have a clear impact (negative and positive) on (dogs name)?
Is there anything else you would like to add about the experience of watching dogs develop through the training in terms of their performance and wellbeing that I did not ask?

The Bond
How would you describe your relationship with (dogs name)?
How has the relationship evolved in time?
What do you like about the relationship?
What do you struggle with about the relationship? Are there any specific instances that affect the relationship?
In your opinion how would (dogs name) answer these last 2 questions?
What is the value of the relationship for you? Why?
Does task work impact the relationship?
Was the use of training tools impacted by the relationship?
Is there anything else you would like to add about the experience with the bond created throughout the training process that I did not ask?

Thank you so much for wanting to participate in this research, your opinion is incredibly valuable, and we truly thank you for your time and your willingness to invite us into your home. This interview as such is in the format of a candid and informal conversation, where there are no right or wrong answers because it is not an exercise with any evaluative intent, and because I am not the expert, you are!
14. MAD Partnership Final In-home Interview Guide

Evaluating a Design / December 2019
MAD Partnerships In-Home Interviews

Introduction
Thank you so much for EVERYTHING!! Especially your patience while participating in this research! As always, your opinion is incredibly valuable, and we truly thank you for your time and your willingness to invite us into your home. This interview as such is in the format of a candid and informal conversation, where there are no right or wrong answers. Its intention is to have the space to review the work we have done in the past year. If at any point during the interview I ask a question that makes you uncomfortable in any way, you can decline to answer or terminate any discussion. In addition, at any time you can withdraw yourself and/or your dog from the study without justification. Recorded data will be anonymised and securely stored; it will be accessed only by the researcher(s) involved in the project and it will be protected by confidentiality according to The Open University’s privacy protection standards, and the consent form you filled out.

Overview
1. General experience of participating in the research
2. General experience of interacting with the prototypes
3. The effect of the research and the devices on the partnership
4. Any unforeseen results
5. If you had been me …
6. Last words
Finally, if at any time I glance down at the page it’s just to make sure I have covered all the questions we wanted to ask. Do you have any more questions/concerns/comments before we begin?

General experience of participating in the research
Overall, how would you describe your participation in this research?
What is your opinion regarding the research activities?
What is your opinion regarding the research visits to your home?
What is your opinion regarding the research communication?
What is your opinion regarding the research aim?

General experience of interacting with the prototypes
Overall, how would you describe your appreciation of the controls in their current state and throughout the research?
What is your opinion regarding the development of the design?
How, if talking to a friend, would you describe the controls and how they function?
General unforeseen results
What did you expect the results of the research to be?
How did these compare to what you feel the results of the research were?
What was missing?
What was unexpected?

If you had been me …
Thinking back to the whole research experience, both from your perspective and on behalf of your dog; if you had been the one carrying out the research, what would you have done differently?

Last words
Is there anything else you would like to add about the experience that I did not ask?

Thank you so much for participating in this research, without your generosity this research would not have been possible. I truly, truly thank you for your time, patience, and your willingness to invite me into your home.
15. User Diaries

Hello!

Introduction

Hello, Das and June.
Thank you again for participating in this study. I am very much looking forward to having you test and use the prototypes, and hope it to be an enjoyable and enriching experience.

This booklet contains information related to the study, an explanation of how to fill in the diary entries and the entries themselves.

Wishing you a wonderful experience of use,
Lukie

The Diary

The purpose of the diary is to capture a record of your experience of use during the course of the next couple weeks.

There is an entry for almost everyday of the study (please refer to the calendar at the bottom of these pages for reference).

The nature of the questions and prompts changes on a daily basis, with some entries being repeated a few times during the course of the study, in order to understand how and if your experience of use changes through time and among the different controls.

Entry forms have 2 questions related to how the prototypes are functioning, a few other questions (approx. 4-10) about the specific area of focus for the day (see calendar below for areas of focus) and a place to reflect on anything not covered in the questions.

<table>
<thead>
<tr>
<th>Date</th>
<th>Form</th>
<th>Function</th>
<th>Relationship</th>
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Day 1: First Impressions

Date:

Baseline
Where are any surprising and/or interesting interactions with the control by your dog or you? (Please describe)

Is there any reason why you are no longer using the control? If yes, please explain the issue and if you have found a way to solve it?

First Impressions

Look at the words listed below, please rate them from 1 to 10 with 10 being the word that most describes your initial impression of the control and 10 being the least

- modern
- cute
- robust
- high-tech
- simple
- canine friendly
- stylish
- toy-like
- decorative
- smart
- other

Thinking about your current light switches, would you say the difference between the function of those and the control is (please circle one option and provide a brief explanation about your choice):

- minimal
- noticeable
- significant

If your dog were to answer this question, what would their response be (please circle one option and provide a brief explanation about your choice):

- minimal
- noticeable
- significant

How to Fill in the Diary

You are welcome to log your entries in whatever form (using this booklet, in separate sheets of paper, in voice notes or emails) and at whatever time convenient for you. However, below is a suggested method for you to make diary entries efficient, yet filled with valuable data.

Step 1: In the morning, take a look at the daily entry, have a quick read and make a mental note of the area of focus.

Step 2: Throughout the course of the day, whenever you or your dog interact or engage with the controls in a way that reminds you of the area of focus for the day, take a couple of seconds to make a note of the thought and/or moment.

The note can be in the form of a quick picture with your phone, a handwritten note, or a comment/ discussion with another person (these notes are referred to as snippets and are meant to reduce the impact keeping this diary has on your day, while recording moments that will be easily accessible to you later on).

Step 3: In the late afternoon or evening, have a cup of tea (tea bags are provided) and take a few minutes to fill in the entry form. As mentioned above please use the format that is the most convenient for you, however, if not using this booklet, please reference the entry number, the area of focus and the date.

Thank you again for your time and feedback!
Day 2: Usage Hypothesis

Baseline
Where there any surprising and/or interesting interactions with the control by your dog or you? (Please describe?)

Is there any reason why you are no longer using the control? If yes please explain the issue and if you have found a way to solve it?

Usage Hypothesis
Do you think these prototypes will be better at providing your dog the ability to turn a light on and off compared to the current light switches (please circle one option and provide a brief explanation about your choice)?

don’t know  yes, by a little  yes, by a lot  no

Do you think these prototypes will result is less errors on the part of the dogs during use compared to the current light switches (please circle one option and provide a brief explanation about your choice)?

don’t know  yes, by a little  yes, by a lot  no

Reflection
Any other comments, feedback, thoughts, reflections you would like to add?

Day 3: Training Feedback Human

Baseline
Where there any surprising and/or interesting interactions with the control by your dog or you? (Please describe?)

Is there any reason why you are no longer using the control? If yes please explain the issue and if you have found a way to solve it?

Training Feedback
What was your overall evaluation of the training experience (please circle one option and provide a brief explanation about your choice)?

easy  hard  neutral  other

What feature, part or detail of the control did you find the most helpful to you during training (please circle one option and provide a brief explanation about your choice)?

Reflection
Any other comments, feedback, thoughts, reflections you would like to add?

Did you think the training materials provided were sufficient? If not please expand on what you think was missing and how they could be improved.

Did you think the training is (please circle one option and provide a brief explanation about your choice), with regards to operating the button?

a lot of learning left  still learning  proficient  expert

Do you think the training time was sufficient (please circle one option and provide a brief explanation about your choice)?

yes  no  other

Do you think these prototypes will result in a higher number of successful attempts (one prompt, one push - light on) compared to the current light switches (please circle one option and provide a brief explanation about your choice)?

don’t know  yes, by a little  yes, by a lot  no
### Day 10: Training Feedback (Dog)

#### Baseline

Where there any surprising and/or interesting interactions with the control by your dog or you? (Please describe):

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Is there any reason why you are no longer using the controls? If yes please explain the issue and if you have found a way to solve it:

---

#### Training Feedback

For the rest of the questions, please take the liberty of answering for your dog.

Do you think the training time was sufficient (please circle one option and provide a brief explanation about your choice)?

- yes
- no
- other

---

Do you think you are (please circle one option and provide a brief explanation about your choice) with regards to operating the button?

- a lot of learning left
- still learning
- proficient
- expert

---

#### Day 11: Usage Hypothesis Interim

#### Baseline

Where there any surprising and/or interesting interactions with the control by your dog or you? (Please describe):

---

Is there any reason why you are no longer using the controls? If yes please explain the issue and if you have found a way to solve it:

---

#### Usage Hypothesis

Now that you have been training and using the controls for a few days have your thoughts changed at all with regards to the following questions (please don’t look at your previous responses before completing today’s questions - when you are done feel free to compare and see how and if your opinions have changed):

Do you think these prototypes have been better at providing the dog the ability to turn a light on and off compared to the current light switches (please circle one option and provide a brief explanation about your choice)?

- don’t know
- yes, by a little
- yes, by a lot
- no

---

Do you think these prototypes have resulted in a higher number of successful attempts (one prompt, one push – light on) compared to the current light switches (please circle one option and provide a brief explanation about your choice)?

- don’t know
- yes, by a little
- yes, by a lot
- no

---

Do you think these prototypes have resulted in less errors on the part of the dogs during use compared to the current light switches (please circle one option and provide a brief explanation about your choice)?

- don’t know
- yes, by a little
- yes, by a lot
- no

---

Do you think these prototypes have been easier to train (please circle one option and provide a brief explanation about your choice)?

- don’t know
- yes, by a little
- yes, by a lot
- no

---

#### Reflection

Any other comments, feedback, thoughts, reflections you would like to add:

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**Day 12: Form**

**Baseline:**
Where there any surprising and/or interesting interactions with the control by your dog or your? (Please describe)?

Is there any reason why you are no longer using the controls? If yes please explain the issue and if you have found a way to solve it?

**Form:**
What do you think about the overall design of the controls (for example: shapes, proportions, size)?

What do you think about the color of the controls?

What do you think about the materials of the controls (for example: heavy, light, hard to clean, sturdy, fragile, etc.)?

Are there any design features (for example: size, materials, color, finish, texture) that you would change or improve upon?

**Day 13: Function**

**Baseline:**
Where there any surprising and/or interesting interactions with the control by your dog or your? (Please describe)?

Is there any reason why you are no longer using the controls? If yes please explain the issue and if you have found a way to solve it?

**Function:**
What do you think about the way the controls work (for example: amount of pressure needed to activate, activation time, feedback)?

What do you think about the feedback mechanisms of the controls (please provide a brief description for each)?

**How would you evaluate the degree of perceptibility (how the parts of the control are detectable by the sensory capabilities of dogs) of the controls (please circle one option and provide a brief explanation about your choice)?**

- completely detectable
- somewhat detectable
- not detectable
- other

**Do you think there is any difference in perceptibility among the different controls (please circle one option and provide a brief explanation about your choice)?**

- yes, small (90nm)
- yes, large (120nm)
- no
- other

**How would you evaluate the level of affordance (how the form of the control’s features suggest the way it may be interacted with) of the controls (please circle one option and provide a brief explanation about your choice)?**

- high
- intermediate
- low
- other

**Reflection**
Any other comments, feedback, thoughts, reflections you would like to add?

**Day 13: Function**

**Baseline:**
Where there any surprising and/or interesting interactions with the control by your dog or your? (Please describe)?

Is there any reason why you are no longer using the controls? If yes please explain the issue and if you have found a way to solve it?

**Function:**
What do you think about the way the controls work (for example: amount of pressure needed to activate, activation time, feedback)?

What do you think about the feedback mechanisms of the controls (please provide a brief description for each)?

**Do you think the timing of the sound feedback is (please circle one option and provide a brief explanation about your choice)?**

- too short
- sufficient
- too long
- other

**Do you think the brightness of the light feedback is (please circle one option and provide a brief explanation about your choice)?**

- too dim
- just right
- too bright
- other

**Do you think the travel of the push-pad is (please circle one option and provide a brief explanation about your choice)?**

- too short
- just right
- too long
- other

What is your favorite feature of the control (for example: button shape, push sensitivity, light feedback, sound)?

What is your least favorite feature of the control (for example: button shape, push sensitivity, light feedback, sound)?

**Reflection**
Any other comments, feedback, thoughts, reflections you would like to add?
Day 14: Relationship

Baseline:
Where there any surprising and/or interesting interactions with the control by your dog or you? (Please describe)

Is there any reason you are no longer using the controls? If yes, please explain the issue and if you have found a way to solve it.

Relationship:
Has the use of the controls impacted your relationship with your dog in any way? (please describe)

Has the use of the controls impacted the way you communicate with your dog in any way? (please describe)

Reflection:
Any other comments, feedback, thoughts, reflections you would like to add?

Day 15: Experiment 1

Baseline:
Where there any surprising and/or interesting interactions with the control by your dog or you? (Please describe)

Is there any reason you are no longer using the controls? If yes, please explain the issue and if you have found a way to solve it.

Experiment 1:
The following experiment is not meant to be incredibly rigid and scientific in nature, but more anecdotal in style. If in carrying out you feel that you are inquiring any level of risk to you or your health please disregard and do not complete.

The hypothesis being tested with this experiment is to create a situation in which the dogs are given a choice of interacting with the control under circumstances which would normally warrant the usage of the control, in order to assess if they have a sense of understanding of the task, and if they will interact with the control without a prompt to change the conditions of the environment.

First, please answer the following question:
Do you think your dog has an understanding of the task of turning on the light?

Have you observed any evidence of your dog's understanding of what happens when using the control? (If yes please describe)

Has your dog operated the control without prompting in the last few days? (If yes, and you have not described it before please describe the details of the event)

Reflection:
Any other comments, feedback, thoughts, reflections you would like to add?
Day 16: Catch-Up Day

Baseline
Where there any surprising and/or interesting interactions with the control by your dog or you? (Please describe):

Is there any reason why you are no longer using the controls? If yes please explain the issue and if you have found a way to solve it:

Catch-Up Day
Use this day to:
- Catch-up on any entries that you did not get a chance to complete
- Try a new way to use the controls
- Add any extra thought you might have
- Look through the snippets and see if anything new comes up
- Note down anything at all regarding the controls

Reflection
Any other comments, feedback, thoughts, reflections you would like to add:

Day 17: Confidence

Baseline
Where there any surprising and/or interesting interactions with the control by your dog or you? (Please describe):

Is there any reason why you are no longer using the controls? If yes please explain the issue and if you have found a way to solve it:

Confidence
How would you describe the concept of confidence in dogs?

Based on your previous answer, please evaluate how confident you feel your dog is when performing task work (please circle one option and provide a brief explanation about your choice):

- very confident
- confident
- somewhat confident
- not at all confident
- other

Reflection
Any other comments, feedback, thoughts, reflections you would like to add:

Day 28: Catch-Up Day

Baseline
Where there any surprising and/or interesting interactions with the control by your dog or you? (Please describe):

Is there any reason why you are no longer using the controls? If yes please explain the issue and if you have found a way to solve it:

Catch-Up Day
Use this day to:
- Catch-up on any entries that you did not get a chance to complete
- Try a new way to use the controls
- Add any extra thought you might have
- Look through the snippets and see if anything new comes up
- Note down anything at all regarding the controls

Reflection
Any other comments, feedback, thoughts, reflections you would like to add:

Reflection
Any other comments, feedback, thoughts, reflections you would like to add:
<table>
<thead>
<tr>
<th>Day 18: Value</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Where are any surprising and/or interesting interactions with the control by your dog or you? (Please describe)?</td>
</tr>
<tr>
<td></td>
<td>Is there any reason why you are no longer using the control? If yes, please explain the issue and if you have found a way to solve it?</td>
</tr>
<tr>
<td>Value</td>
<td>Have these changes provided or taken away any value to your dog?</td>
</tr>
<tr>
<td></td>
<td>Have these changes provided or taken away any value regarding your relationship with your dog?</td>
</tr>
<tr>
<td></td>
<td>If your dog were to answer the last question, how would they respond?</td>
</tr>
<tr>
<td></td>
<td>Based on your experience to date: how much value would you say having the controls installed in your home has provided to you? (Please circle one option and provide a brief explanation about your choice).</td>
</tr>
<tr>
<td></td>
<td>very valuable</td>
</tr>
<tr>
<td>Reflection</td>
<td>Any other comments, feedback, thoughts, reflections you would like to add?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 19: Experiment 2</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Where are any surprising and/or interesting interactions with the control by your dog or you? (Please describe)?</td>
</tr>
<tr>
<td></td>
<td>Is there any reason why you are no longer using the control? If yes, please explain the issue and if you have found a way to solve it?</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>The following experiment is not meant to be incredibly rigid and scientific in nature, but more anecdotal in style. If in carrying it out you feel that you are inquiring any level of risk to you or your health please disregard and do not comply.</td>
</tr>
<tr>
<td></td>
<td>The hypothesis being tested with this experiment is to evaluate if the contrasting color of the push pad of the control helps the dog find the control quicker within the home environment.</td>
</tr>
<tr>
<td></td>
<td>During the day, move the control from its regular place if this presents any risk to your safety please do not attempt. Let about 1-2 hours go by without adding your dog to interact with the control. Then, issue the command to operate the control without adding any other type of prompts (physical movement, glancing, but feel free to issue a few more verbal commands).</td>
</tr>
<tr>
<td></td>
<td>Now, please answer the following questions:</td>
</tr>
<tr>
<td></td>
<td>When you issued the prompt how did your dog respond when realizing the control was not in its usual place?</td>
</tr>
<tr>
<td>Did they search for the control? (Please circle one)?</td>
<td>yes</td>
</tr>
<tr>
<td>If yes, did they locate the control? (Please circle one)?</td>
<td>yes</td>
</tr>
<tr>
<td>If yes, how long did it take them to find the control?</td>
<td></td>
</tr>
<tr>
<td>Reflection</td>
<td>Any other comments, feedback, thoughts, reflections you would like to add?</td>
</tr>
</tbody>
</table>

How would you describe your dogs state and activities during this time (for example: same as always, confused, anxious, tail up, tail down)?

If your dog starts to show signs of frustration or confusion, go ahead and re-issue the prompt and glance towards the control. |
| Did they search for the control? (Please circle one)? | yes | no |
| If yes, did they locate the control? (Please circle one)? | yes | no |
| If yes, how long did it take them to find the control? | |

How would you describe your dogs state and activities during this time (for example: same as always, confused, anxious, tail up, tail down)?

If your dog starts to show signs of frustration or confusion, go ahead and re-issue the prompt and glance towards the control. |
| Did they search for the control? (Please circle one)? | yes | no |
| If yes, did they locate the control? (Please circle one)? | yes | no |
| If yes, how long did it take them to find the control? | |

How would you describe your dogs state and activities during this time (for example: same as always, confused, anxious, tail up, tail down)?

Reflection | Any other comments, feedback, thoughts, reflections you would like to add? |
Day 20: Final Hypothesis Interim

Baseline
Where there any surprising and/or interesting interactions with the control by your dog or you? Please describe?

Is there any reason why you are no longer using the controls? If yes please explain the issue and if you have found a way to solve it?

Usage Hypothesis
Now that you are nearing the end of using this version of the controls, have your thoughts changed at all with regards to the following questions please don’t look at your previous responses before completing today's questions – when you are done feel free to compare and see how if your opinions have changed.

Do you think these prototypes resulted in a higher number of successful attempts (one press, one push - light on) compared to the current light switches (please circle one option and provide a brief explanation about your choice)?

- don’t know
- yes, by a little
- yes, by a lot
- no

Do you think these prototypes resulted in less errors on the part of the dogs during use compared to the current light switches (please circle one option and provide a brief explanation about your choice)?

- don’t know
- yes, by a little
- yes, by a lot
- no

Do you think these prototypes were easier to train (please circle one option and provide a brief explanation about your choice)?

- don’t know
- yes, by a little
- yes, by a lot
- no

Reflection
Any other comments, feedback, thoughts, reflections you would like to add?

- 
- 
- 
- 

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ARTICULATING YOUR ACI ETHICAL VALUES

8. GUIDING STATEMENTS

3. RESEARCH ACTIVITY SCENARIO PLANNING

Think about the different types of activities outlined in the research plan which might be of interest to ACI.

The research questions are:

1. Are there any ethical issues involved in the research activities outlined in the research plan?

2. How would you address these ethical issues if they were identified?

3. What are the potential impacts of the research activities on participants and society?

4. Are there any measures in place to mitigate these impacts?

5. How would you ensure the safety and well-being of participants during the research activities?

6. Are there any potential conflicts of interest that need to be addressed?

7. How would you ensure the confidentiality and privacy of participant data?

8. Are there any legal requirements that need to be met in conducting the research activities?

9. How would you ensure the accuracy and reliability of the research data?

10. Are there any potential implications for the research plan that need to be considered?

11. How would you ensure the dissemination of the research findings in a responsible and ethical manner?