Dog Computer Interaction – Methods and Findings for Understanding how Dogs' Interact with Screens and Media

by

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You can tell your story with the dog.

Or you can tell the story the dog told you.

As part of this research, the coding for Chapter Six in MATTLAB on dissecting dog images for image processing software was conducted by Huilan Luo. The coding for the DoggyVision Java program in Chapter Eight was done by Brendan Cassidy.

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Abstract

The ubiquity of technology has resulted in machinery occupying our homes, increasing the exposure and use of screen devices to dogs. Dogs have long viewed computer screens, yet the usability of, and the dog's attention to, these screen devices remains under-researched. This research focuses on investigating a dog's attention to screens and the human's and researcher's evaluation of this. The specific aim was to determine how to capture this attention through both technology devices and coded methods. The research contributes to the knowledge area of dogs' screen interactions and dog-computer interaction (DCI) methods within animal-computer interaction (ACI). It adds literature in the novel field on dogs' use of screens to watch media and explores method transference from human-computer interaction (HCI). This helps lay down the foundation for the DCI community and gives indications on the future directions of DCI research with screen interfaces.

The research is explored through four research questions: Can methods be developed that can capture a dog's attention to single, multiple and dog-activated screens in a dog-centric manner? When different media are presented to dogs, do they show preferences, and do they follow preferred media as they move from one screen to another? In what ways can a dog's attention to screens be quantified in a useful way from an owner, computer and researcher standpoint? and What effect does taking a dog-centric philosophy have on the study of dog-computer interaction?

This thesis is heavily embedded within the ethical philosophical stance of dog-centric research. This shapes the methods used and the technology created. It focuses on dog user requirements that allow for untrained interaction allowing the dog to explore the technology in a natural way. In this light, the role that dogs take within the method and evaluation process and the interaction between the modalities of human, dogs and computers are examined. This thesis shows that it is possible to capture a dog's attention to screen interfaces from the researcher, the dog owner and the dog itself within the dog-centric philosophical approach. These findings are derived from three empirical studies and two research tools.

The two research tools presented deliver DCI enhanced interpretive feedback for DCI research in tool 1 and provide a way of modelling the dog user in tool 2. Tool 1 enhances, from a human standpoint, the analysis of a dog's attention by facilitating the owner to be an informed observer through providing a Dog Information Sheet (DISH) on dog behaviour. Tool 2 uses information from the owners of 196 dogs to craft six role-based personas across different breeds, ages and home situations to aid researchers during the initial stages of research and design in DCI. This also provided a data storehouse of dog information.

The three empirical studies narrate a story across finding ways of automating the detection of a dog's attention to TV like screens, to detecting a dog's attention to media across multiple screens and then allowing the dog to trigger its own media on a screen. Study one used MATLAB to classify where a dog's head is facing within three variables (left/centre and right) within a high accuracy of above 82%. The second study investigated a dog's attention across multiple screens using video evidence, analysed by a researcher, to classify a dog's attention. This indicated that dogs did not follow media content from one screen to another and showed that they preferred a favoured screen. In this study, it was found dogs prefer dog-based media and had short (under 3 seconds) attentive glances. The third study concluded the thesis using a

specially designed screen device that was triggered by the dog's proximity, to investigate a dog's attention, over a two-week period, to a dog-activated screen system that plays media. This study demonstrated that dogs would attend to a screen device playing media and that proximity can be used as an activator of media content.

The work concluded by listing contributions regarding the design, methods and principles of screen systems for dogs. Initial findings are provided for the DCI field of low attention times with dogs and screens (approximately 3 seconds) and that the videos attended to by dogs were mainly of dog context. In this regard, short media clips should be used with dogs. Dogs throughout this thesis did not seem to attend much to screens preferring to watch nothing and often maintaining or keeping the same level of attention towards dog imitated machines.

One of the main contributions this thesis provides are empirical methods to provide some insight into how dog-centric methods can be used in DCI. These methods indicate the importance of the data gathered from the time spent on task with a device is as valuable as the time spent without the device. The tools provided form a contribution of ways to model the dog user and enhancing the feedback from the owner leading to the conclusion that the optimal dog-centric environment is with high dog autonomy and low human involvement during data collection. Within this, discussion is given on the tension within the dog-centric philosophy method approach between the dog and the data where the research philosophy reflected in the principles given were found to hindered data collection but do ensure the dogs welfare.

For the ACI field in DCI this thesis suggests that the researcher determines the pool of dogs that the researcher is considering before choosing the method and system advocating for getting to know your end user. This narrative is followed by an exploration of potential growth areas of interactive media technology for dogs, identifying regions of DCI that could be further studied such as multiuser systems, further exploring how the human impacts DCI research, the ACI to HCI transference, investing further into what is interactivity in ACI and dog-driven devices and lastly the continue to develop dog-centric methods for DCI research.

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I also am indebted to the Animal Computer Interaction (ACI) community who provided a space for my research to grow. Through paper iterations, and the constant encouragement of the validity of my work and the ACI's own unique take on how to research with dogs, this thesis grew within the ACI community and myself.

Finally, I would like to thank the two most central things to me; my dad, Robert Hirskyj, and my dog Zack. My dad supported me, both financially and emotionally, through this whole process believing in me undoubtedly (even when I didn't submit in 2 and a half years) and providing the love and support I needed. He also bought me the missing piece of myself: my dog, Zack.

Dedication

Woof woof. Bark. Woof woof woof. Woof woof woof bark. Grrr. Woof woof woof woof.

You are a good boy.

Abbreviations

Animal Computer Interaction	ACI	The study of non-human animals and technology.
Human Computer Interaction	HCI	The study of humans using technology.
Dog Computer Interaction	DCI	The study of dogs using technology.
Child Computer Interaction	CCI	The study of interaction design with children.
User Centred Design	UCD	A framework of processes in which the needs, wants, and limitations of end users of a product, service or process are given extensive attention at each stage of the design process.
User Interface	UI	The means by which a user and computer system interact, often regarding software and devices.
Dog		Dogs within this study is in reference to domesticated dogs (canis lupus familiaris or canis familiaris) unless specified.
Animal		Animals within this thesis are defined as non-human animals.

Publications Relating to Thesis

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Chapter 1

Introduction

1.1 Introduction

This introductory chapter will discuss the main themes running throughout this thesis framed around the contents held within. At the beginning of this thesis, the animal-computer interaction (ACI) field was in its infancy with the ACI special interest group (SIG) just being inaugurated a few years prior (Mancini, 2011). Whilst dogs have been repeatedly and prevalently studied within ACI, the foundation had, and arguably still has, to be laid for researching dog-computer interaction (DCI) to develop a series of standard practices which are not yet available within this field. In this way, this thesis grew much with the new field of ACI in rather an exploratory manner.

This work is initially motivated by gap in knowledge of how dogs attend to screens and videos given that this is a common output for computer based systems. In 2013, there were a handful of research works on dogs' interaction with computer screens (Williams et al., 2011; Somppi et al., 2012). These works were mostly focused around dogs' discretion and recognition of images on screens. With the growing occurrence of DCI technology, both for systems for dogs in the workplace (Zeagler et al., 2016) and for commercial products (DogTV, 2016), the use of screen technology becomes a valuable interaction research area for the future of ACI work. Screen technology that a dog has access to has become ubiquitous (tablets, phones, laptops, etc.), opening several questions on how a dog uses media technology by way of attending to screens. In this way, the motivation for methods to quantify and categorise a dog's attention to screens has become a point of interest for DCI researchers.

This investigation is foreshadowed by the increasing positive attitudes towards dogs within Western countries (George et al., 2016) which have led to the legislation of 'sentient being' rights. This sentient legislation grants rights to dogs comparable to the rights given to children (Hodgson, 2015), provoking a rethink of societal and researchers' attitudes. There is, within this dialogue, a move away from speciesism, that is, human superiority over exploiting animals (Dunyer, 2013). This migration of attitude, that is, stepping away from dogs as proprietorships, establishes the position of methods and theories suggested and applied within this investigation, accumulating in a dog-centric point of view. In this way, unlike traditional animal science, in the research the dog is given rights comparable to a human user, rather than being considered as a laboratory animal.

The main work within this thesis is concerned with capturing and modelling how dogs attend to computer screen technology using a dog-centric approach to lay the underpinning foundations, bringing forward the findings and methods created. From this research focus, two main themes emerged: *investigating how dogs attend to screen technology* and *investigating how to capture this attending behaviour methodologically in a dog-centric fashion*. This thesis, therefore, seeks to bring methods into DCI, and thus ACI and human-computer interaction (HCI) through transference, to enable the capturing of attention within the philosophical scope of dog-centric research. This research is conducted over two research tools (Chapters 4 and 5), three empirical studies (Chapters 6, 7 and 8) informed by the author's philosophical approach to research and a set of ethical principles (Chapter 3).

1.1.1 Structure

The remainder of this chapter provides an introduction into ACI (Section 1.2) looking specifically at DCI (Section 1.3), exploring what it means to be a dog and what is termed as interaction within this context. Following this, a discussion is made on the user(dog)-centric philosophy used within this thesis (Section 1.4). This is concluded (Section 1.5) by providing a synopsis of the rest of the thesis document.

1.2 Animal-Computer Interaction

Whilst the discipline of ACI was only recently founded (Mancini, 2011), animals have been using technology for a long time. Early studies of dogs and technology focused on tracking animals and on studying their behaviour (Hume & Ganong, 1956; Skinner, 1959). Later work studied animal-human communication in the 1980s (Rose et al., 1987) and 1990s (Reisss & McCowan, 1993), with more recent research looking at modernising farming (Rossing & Hogewerf, 1997). These early animal-technological systems were carried out across varying disciplines from engineering and psychology to biology, often focusing upon the end-goal scenario rather than the design process and interaction style. A design focus has emerged in recent years including studies within farm industries (Rossing & Hogewerf, 1997), research laboratories (Carlson, 2009), conservation studies (Samuel & Fuller, 1994) and studies for niche projects

(Resner, 2001; Lee et al., 2006).

For those interested in the design of technologies for dogs, the research focus slightly changed in 2000 when Savage et al. (2000) developed a project named UNAM-CAN, allowing animal-human communication through interfaces. In this work, the focus was on a dog carrying out a task. This project applied knowledge from human-machine interface design and began the transference of methods from HCI to ACI. The aim of this work was primarily to investigate if dogs can deconstruct executable sequential tasks via wearable computers (Savage et al., 2000).

In 2001, research with animals moved along further with a niche dog communication project by Resner (2001) who, unlike previous researchers, changed the focus from device usage to interaction design, joining together the fields of animal behaviour and HCI. Within his work, Resner (2001) referenced interaction design theories such as user-centred design (UCD) regarding communication modes and usability. Lee et al. (2006) followed up Resner's (2001) work with an ACI exploration with chickens. Lee et al. (2006) looked at computing the human-animal bond through an automated jacket wearable by the chickens that simulated a farmer's stroke. Weilenmann and Juhlin (2011) went further in this direction by focusing on interaction methods looking to move ACI beyond dyadic (group of two) relationships, suggesting methods to include more than one animal within the interaction.

Mancini brought many of these advances and philosophies together in her ACI Manifesto (2011), which called for ACI to be a discipline around specific intentions. The aims of ACI as a field were summarised as

- understanding the interaction,
- developing user-centred approaches and
- informing the development of the interactive technology to improve support and foster relationships (Mancini, 2011).

Following the publication of the ACI Manifesto, a SIG (Mancini et al., 2012) was formed at the ACM SigChi conference (CHI2012), nurturing the growth of the newly formed ACI community in HCI. Subsequently, this was followed by the first, the second and more recently the third International Conference on Animal-Computer Interaction (2016). During this period, and with the community thriving, ACI has grown roots into a range of disciplines including game development (Westerlaken & Gualeni, 2014), animal behaviour and welfare (Winters et al., 2016) and HCI (Valentin, 2014). The work being done in ACI is across a number of different purposes and settings (Webber et al., 2016) and is, in its work, creating theories and developing methods (Asplin & Juhlin, 2016). The ACI field is explored further through a literature commentary in Chapter 2, which analyses the current work.

1.3 Dog-Computer Interaction

Within ACI, dogs, holding a unique position within our households as the oldest domesticated animal (Dewey & Bhaget, 2002), are the most studied animal species (Table 2). With their evolution and origin speculated to be diverged from wolf-like canids in Eurasia 40,000 years ago (Skoglud et al., 2015), dogs have evolved behaviours hand in hand with human companions (Berns et al., 2012). This co-evolution with humans has seen their roles within society change from being primarily functional, that is, hunting, hearing, assisting and protecting, to an increasing role as companion pets often referred to as 'man's best friend' (Derr, 2014). This early juxtaposition of roles is highlighted in Voltaire's *Philosophy Dictionary* (1764, p. 24) translated as follows:

'It seems that nature has given the dog to man for his defence and for his pleasure. Of all the animals it is the most faithful: it is the best friend man can have'.

The human-dog bond has been shown to be mutually beneficial and dynamic (Coren, 2001) with the attendant research area, anthrozoology (human–animal studies), being taken up by psychologists, anthropologists and ethologists alike (Mills, 2010).

As mentioned in Section 1.2, dogs have been attending to screen technology for a long time, unintentionally through passive gazing or intentionally through systems designed for humans. With dogs now having more access than ever to interactive technology, this thesis will investigate the dog's foundational attention towards screen technology through empirical studies. Study 1 (Chapter 6) tracks the dogs' head movements, study 2 (Chapter 7) investigates the dogs' screen choice and study 3 (Chapter 8) explores a specially designed dog-driven screen device. This work seeks to help formulate and understand how dogs attend to screens to help inform future dog-media technology research and the wider DCI field. These studies are supported with two new research tools (Chapters 4 and 5) which seek ways of modelling the dog user for initial design (tool 1 [Chapter 4]) and presents a way of enhancing feedback from the human dog owner (tool 2 [Chapter 5]).

Recently, in DCI systems, interactive applications have been developed to allow dogs to drive the use of interactive systems. These include haptic interfaces (Byrne et al., 2016; Lemanson et al., 2015), posture systems (Majikes et al., 2016), screen interfaces (Valentin, 2014) and pulley systems (Robinson et al., 2014).

Most ACI systems currently in use are goal focused with the primary aim being to build systems that achieve a set goal as opposed to there being an emphasis on exploring the dog's use of technology. Study 3 (Chapter 8) seeks to bring an understanding into the area of a dog-driven media system through an exploration into the normal (that is, untrained) use of these screen systems following an investigation on their human-activated screen use (tool 2; Chapter 5). This includes exploring a dog's use of dog-activated screen systems that are triggered by the dog to play media (study 3; Chapter 8).

1.3.1 What Is a Dog within DCI

What it means to be a dog and what a dog can be expected to do are both questions that are worth debating and are questions that will be contemplated throughout this thesis. What it means to be a dog still holds varying contexts from free-roaming dogs that are their own masters and highly adapted scavengers, to those that are our pets (Coppinger & Coppinger, 2016). With over 340 breeds recognised by the Federation

Cynologique Internationale (FCI), the world governing body of dog breeds, what a dog looks like can vary and is continually evolving as humans build variants (Melina, 2010). Dog breeds are evolved to hold different capabilities to suit their given role, such as bloodhounds for discerning scent over great distances for hunting. Within this body of work, focusing as it does on screen interaction, the dogs referred to are pet dogs, kept within the home, unless otherwise specified.

The versatility of breeds requires that any technology made for dogs, and the reliance on the extent to which the dog can to attend to technology, has to be quite variable. As the ACI field grows, what a dog can and cannot do is being challenged by building up a foundation of knowledge about a dog's psychology and behaviour around interactive systems. In this thesis, it is assumed that a dog consciously chooses to attend to visual stimuli and chooses its actions in a sentient way.

1.3.2 What Is Interaction in Dog-Computer Interaction

DCI is the study of how dogs interact with computers. This interaction always includes the dog and the technology but often will also include a human dog owner. The study of DCI aims to enhance the interaction by developing methods, philosophical stances and theories within this space. However, the terminology of what it means to have an interactive system has not been defined within DCI. Interaction can be seen in a broad way as the framing of the relationship between people and the objects designed for them (Buchanan, 1998). In DCI, as in HCI, interaction is more often seen as an archetypal structure, the feedback loop (Dubberley et al., 2012) where reference is made to 'an interaction,' which is the communication between system and user. Within this definition, interaction in DCI refers to the way that the dog reacts to the technology and in return the way that the technology then responds to the dog in a feedback loop.

The term 'interaction' is therefore used throughout this thesis, but it is acknowledged, in the sense of the Buchanan definition of interaction, that the degree to which a dog can meaningfully interact with a computer system is unknown as a dog's intentions and what dogs perceive as possible to do within a computer system are unidentified. In HCI, this degree of representation is known as the theoretical framework coined by Norman (1988) as 'the gulf of execution' and can be modelled in DCI (Figure 1). Part of this thesis explores this 'gulf' of what is the dog user's intentions and considers if this can be represented, directly perceived and interpreted. This is explored through trying to capture the dog user's actions. In human-human and human-computer communication, there is a rich two-way feedback loop of interactivity where there is derived meaning gathered from the actions taken, the interpretation, and in return the output delivered. There also appears evidence of this feedback loop in dog-human communication between dog and trainer, such as when they interact. A question present within this thesis is whether this cause-effect feedback loop occurs when a dog interacts with the screen or not.

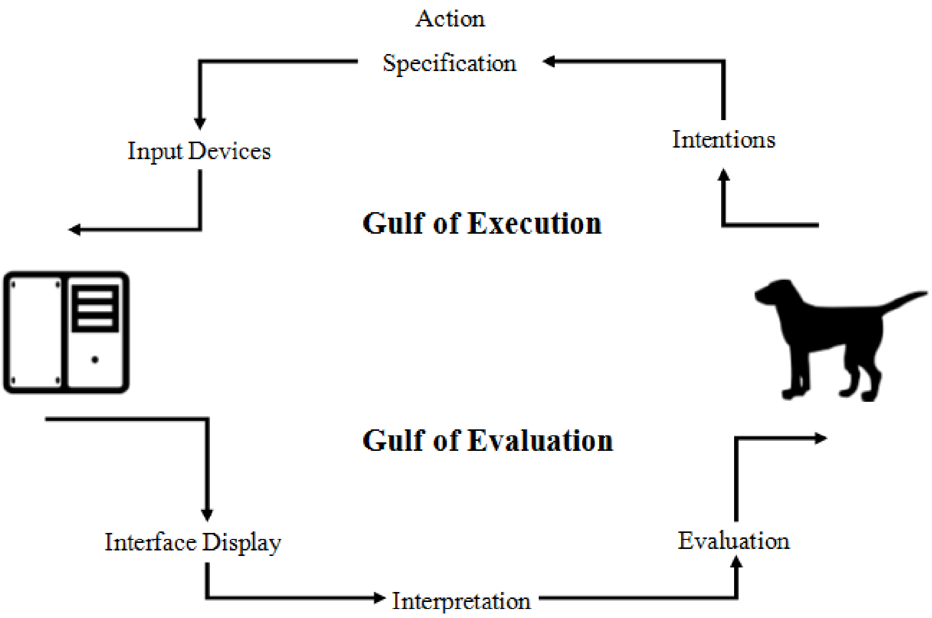

Figure 1. Representation of the gulf of execution in DCI systems

It is in this way that this thesis explores the gulf of execution, the top half of the feedback loop, and it is acknowledged that the loop may not be fully closed. This is due to, in DCI, the bottom of the gulf (evaluation) being unknown, that is, a dog's interaction can be captured, but what meaning this has to the dog is unknown. It is in this way that this thesis is not about truly interactive systems but more about exploring elements within them. These elements are 'looking at' behaviours and 'attending to screens', but not the reasoning behind a dog's attention (intentions). Within this space, all we can do as researchers is interpret these behaviours. This same interpretation is very often the case in children (CCI) and sometimes also adults in those cases where it can be hard to draw at the intention behind the interaction loop. As DCI is a new field, there is clearly more research to be undertaken to explore these gulfs. Within this thesis, the extent to what a dog can attend to, rather than to define the interaction, is explored.

1.4 Dog-Centred Approach

This thesis approaches DCI from a user-centric paradigm. As discussed in Mancini's (2016) ethical guidelines, a user-centred approach helps support the better development of ACI as a discipline by recognising welfare, consent, animal-centred frameworks and principles. The ethical approach described goes beyond current regulations and guidelines associated with research with animals. DCI systems often have more than one user: the dog and the human. These two users can interact with the screen differently: human only, dog and human and dog only user. The dog-centric approach taken here is to make the system more dog focused by exploring to what extent the dog can be given power to control systems without human intervention. This thesis therefore focuses primarily upon the dog user with the human taking a secondary role. The reasoning behind this centring is to ensure the welfare of dogs whilst studying their use of computer systems. This is hoped to create more usability in DCI systems through simply giving dogs systems and seeing how they react, drawing notes directly from this. It is in this way that it is hoped that the dogs can help inform the system, and thus, the system becomes more centred around the dog user.

The ethical position of this research is to go beyond consent into equality, laid out within the research philosophy section (Chapter 3), based around derived principles of dogs attending to screen and media (Section 3.2.2). This dog-centric approach is taken within an agential realism stance (Barad, 2007), that is, as a researcher, we are ultimately connected into the results and within the interaction itself as these objects within DCI cannot exist without each other. It is in this way that the human and the ethical issues, that is, a dog's welfare, can never be fully taken out of the system.

Whilst most dogs are our pets with limited choices shaped by our behaviours (Berns et al., 2012), they still regularly do make choices. These choices, effectively evidence of decision making, have traditionally been studied with dogs through considering preference testing, giving insight into dogs' cognitive processes (Pongracz et al., 2003). These preference tests allow various measurements of animals' behaviour and can be recorded through machinery or interpretation. Preference tests with dogs have been conducted to compare dogs against wolves (Gacsi et al., 2005) with objects (Tapp et al., 2003) and in medicine. These allow the dog to have an input, that is, a choice.

Given that dogs have shown to have the ability in situations to choose, this thesis aims to study this possibility within screen contexts by considering attention. In dog computing, the support of choices is typically between two competing possibilities (e.g. A or B). This thesis extends preference testing to include a non-choice scenario where the dog does not have to engage with the system if it does not want to (e.g. A, B or neither). This is with the understanding that the dog does not 'like' the preference that it chooses but instead that it is attending to it.

Owner feedback is often used in ACI (Baskin et al., 2015; Westerlaken & Gualeni, 2014) as a way of maintaining welfare and judging interaction. Within this thesis, the relationships that the dog owners have with their dogs are used to enrich the feedback about the interaction in a proxy manner. This relationship is explored to find methods to enrich this feedback to help bring out the interpretation behind the dog's behaviour, that is, not only what the dog is doing, but why. This work of enriching the toolset for researchers from the dog perspective is then taken further by creating personas to explore modelling a dog user within DCI, helping to put a face to often intangible data (tool 1; Chapter 4).

Screen systems for dogs, to date, have relied upon trained responses initiating the interaction (Zeagler et al., 2016) within the set boundaries of human governance. In study 3 (Chapter 8), the use of proximity tracking is used as an interaction modality for DCI screen systems to explore if it is possible to create dog-driven systems and, from this, to explore the impact of these systems. This brings the previous findings together to help present another dog-centric method of capturing a dog's attention to screens.

1.5 Synopsis of Thesis Document

This thesis aims: *'To see how dogs interact with media technology over screen systems; to design methods of tracking and mechanisation of the dogs' use of screen technology; to develop methods and theories to aid the design of screen technology for dogs in an animal-centric fashion'*. During the pursuit of the laid-out goals, further objectives were met, adding to the existing DCI community base of knowledge, investigating a dog's attention to screens and identifying future research directions for dog media technology. The aims and objectives that were met are discussed in the concluding chapter (Chapter 9).

This thesis investigates a *dog's attention to screen technology to view media* by looking at methods of capturing this attention and seeing how dogs attend to screens. These methods led to key findings on how to capture a dog's attention to screens by creating ways to interpret this behaviour (summarised in Chapter 9). Study 1 (Chapter 6) initially explored ways of capturing a dog's screen attention behaviour through image classification systems based on head position. This screen attention was then investigated with multiple (three) screens in study 2 (Chapter 7) to see if a dog would follow media content across screens and to study the dog's attention choices in regard to screen placement. Lastly, a system in study 3 (Chapter 8) was built to test dogs' use of a dog-initiated system. These studies are wrapped around by ethical and philosophical guidelines (Chapter 3) and principles for dogs attending to screens and media (Section 3.3.2).

Overall, methods of capturing and labelling a dog's attention to screens were explored in study 1 (Chapters 6), study 2 (Chapter 7) and study 3 (Chapter 8). These empirical studies were supported with research tools. Tool 1 (Chapter 4), considered methods to help initial designers model a dog within screen systems for media; tool 2 (Chapter 5) explored ways of measuring a dog's attention by using the dog owner as a proxy voice.

1.5.1 Structure of the Thesis

So far, this chapter has outlined the main purpose of this thesis: 'Dog-Computer Interaction—Methods and Findings for Understanding How Dogs Interact with Screens and Media'.

The figure below shows how the individual sections of this thesis are structured (Figure 2).

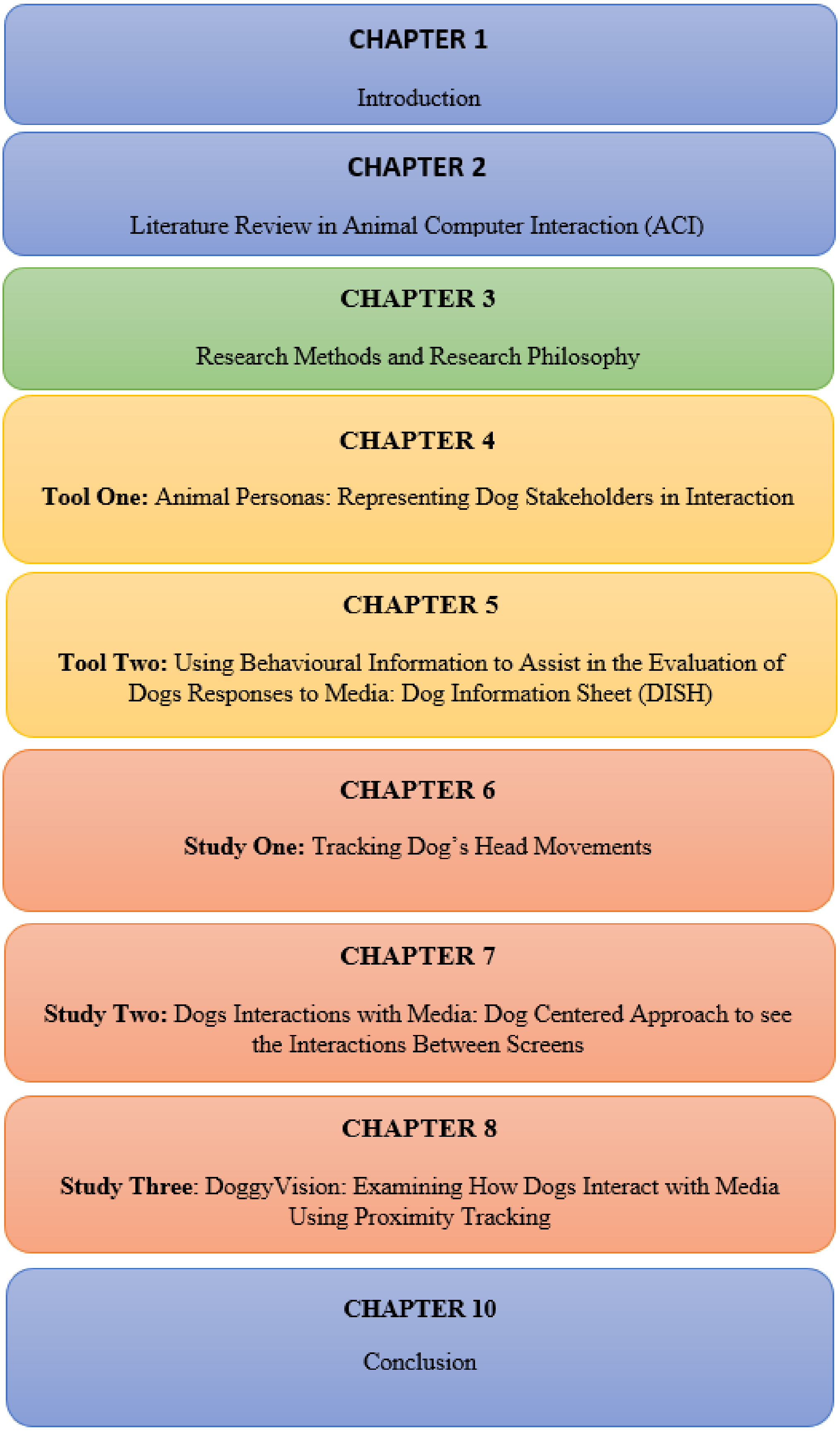

Figure 2. Structure of thesis showing chapters: structural (blue), theory (green), tools (yellow) and studies (orange).

1.5.2 Literature Review and Research Methodology

To fully understand the current situation of DCI, it is necessary to firstly explore the field of ACI through a literature review (Chapter 2). This review identifies topical areas relating to dogs and screen technology within the field of ACI. The review also highlights relevant literature and theory grounding the undertaken research work. This is laid out through a discussion on relevant technologies, methodologies, theories and ethics frameworks that lay the foundations for the subsequent research work.

1.5.3 Theories and Tools to Centre DCI Media Technology

The philosophical stance surrounding this thesis of dog-centric DCI is explored in Chapter 3 and the position outlined in that chapter was used throughout this research. The dog's role in DCI is explored in study 2 (Chapter 7) to investigate ways of including the dog within the system. This thesis then looks at tools to use within DCI and screen media through the initial human-only design stages of DCI through creating role-based personas in tool 1 (Chapter 4). These personas allow for a dog's influence to be present throughout the DCI processes. Different users are then explored: the dog as the user and the human as the observer. This is explored in tool 2 (Chapter 5) by using the relationship between dog and owner to improve the reporting of dog screen behaviour by creating an informed observer of the dog owner. It is through these studies (1, 2 and 3) and tools (1 and 2) that this thesis aims to bring methods to DCI through quantifying a dog's attention to screen interfaces and the humans' evaluation of this behaviour.

1.5.4 Studies to Investigate Dogs' Media Choices and Tracking Watching Behaviour

Study 1 (Chapter 6) investigated the automatic tracking of dogs' vision using image processing. MATLAB was used by a third-party researcher to analyse images to pinpoint, within three possible areas, where a dog's head was facing (left, right and centre) for the remote tracking of dogs' vision.

1.5.5 Studies to Investigate Dogs' Screen Choice

Having used a method to track and analyse a dog's head movements and having identified the dogs' screen content biases in previous works, study 2 (Chapter 7) investigated dogs attending to multiple screens (three) to see if the screens' placement affected the dogs' attention. This included looking to see if a dog could follow and favour videos across multiple screens.

1.5.6 Studies to Investigate Dog-Driven Media Technology in DCI

Through the above studies (one and two) it became apparent that whilst dogs attend to screen systems playing media, currently a study has not been conducted to allow a dog to turn on and off a screen device. The concluding third study (Chapter 8) investigated the use of a dog-activated system coined DoggyVision that turned on screen content when a dog was within the trackable area using proximity tracking. This study brought a method into DCI for a dog to trigger its own media interactions whilst providing a way to capture a dog's watching behaviour through automatically videoing and logging these interactions.

1.5.7 Concluding Work and Research Contributions

The research investigations delivered outcomes and theory which can aid future and current DCI and ACI work, particularly bringing methods and empirical findings for screen technology playing media. Chapter 3 frames the research method and philosophy and in Section 3.2.2, initially puts into place principles for dogs attending to screen and media. Chapter 9 then outlines the empirical findings against these principles and research philosophy to give the initial foundation to DCI, allowing growth and direction for future work. In this section, the research contributions are discussed in regard to the design of screen media for dogs, methods to study a dog attending to screens and principles for working with dogs.

The contributions of this thesis to research are initially to the development of the field of DCI, but also to the surrounding body of research, both ACI and HCI, through its use of methods from these fields. The contributions come in three parts: the methods and theories created, the initial empirical results found and from this the reflections upon the principles and philosophical approach to dog-centric research.

1.6 Research Questions

This research asks key questions to the field of DCI and thus ACI subsequently. These questions are as follows:

1. Can methods be developed that can capture a dog's attention to single, multiple and dog-activated screens in a dog-centric manner?
2. When different media are presented to dogs, do they show preferences, and do they follow preferred media as they move from one screen to another?
3. In what ways can a dog's attention to screens be quantified in a useful way from an owner, computer and researcher standpoint?
4. What effect does taking a dog-centric philosophy have on the study of dog-computer interaction?

These four key questions will be explored throughout this thesis and further reflected upon in the concluding chapter to see how well these questions have been met through the research conducted within this thesis, and the implications of the findings derived.

1.7 Conclusion

This introduction paints an overall picture of the thesis context, highlighting the main research themes. The next chapter is a literature review of the field of ACI considering technologies and methods used in ACI as well as ethical and theoretical stances that have been adopted. This review lays the foundations of previous work that will be later built on through the tools and studies.

Chapter 2

Literature Review in Animal Computer Interaction

"I'm setting up a MySpace page, but I can't figure out how to let my friends sniff me over the Internet!"

Chapter 2

2.1 Introduction

Animals' well-being, behaviours and physical characteristics have long been studied. In the late twentieth century, studies were conducted into the ways that some animals behave in human-animal situations. Subsequently, these studies have moved towards the ability of animals to assist humans and thus improve the human condition (Dixon, 1998). As technology has become embedded in the human condition, it has also become of interest in terms of how it affects the human-animal relation. Technology today has been shown to be useful for playful interactions between humans and animals (Pons et al., 2015; Westerlaken & Gualeni, 2014) and for monitoring animals (Mancini et al., 2014; Resner, 2001), training animals (Morrison et al., 2016) and supporting animals that care for humans (Robinson et al., 2014; Zeagler et al., 2016).

Animal-computer interaction (ACI) studies, among other things, how animals interact with technology. As a relatively new field, it has taken reference from human-computer interaction (HCI) (Mancini et al., 2014; Resner, 2001; Westerlaken & Gualeni, 2014), which led to an early focus on studies of usability of technology and the user experience of animals to influence the design of interactive solutions (Lee et al., 2006; Tan et al., 2006). Frameworks have been constructed for ACI technology in interaction design (Tan et al., 2006), HCI (Westerlaken & Gualeni, 2014), ubiquitous computing (Mancini et al., 2014) and game design (Mancini et al., 2014; Racca et al., 2010). Some of these frameworks aim to reveal the role of technology within a human-animal interaction (Mancini et al., 2014; Westerlaken & Gualeni, 2014), whilst others aim to minimise the human role to more fully design the animals' unique needs, as presented within this thesis. Whilst the motivation of animal-computer technologies is often welfare based (Mancini et al., 2014), ACI also attends to other aspects, including the pet entertainment and holistic well-being sector where many commercially available products exist.

Academic studies pertinent to the design of ACI technologies have increased over the last six years since the publication of the ACI Manifesto (Mancini, 2011), the introduction of the ACISIG at the CHI conference (Mancini et al., 2012), the first, second, third and now fourth International Animal-Computer Interaction Symposium (2014, 2015, 2016, 2017), and workshops at major HCI conferences (BHCI@ACI, NordiCHI 14/16, ISWEL). As interest has grown in this field the workshops and events have been increasing in speciality. For example, HCI goes to the zoo at CHI'16.

As narrated in the introductory chapter, this literature review chapter aims to explore the topics relevant in ACI towards the research subsequently reported. This chronicle begins by briefly exploring what ACI is and considering how the conjoining fields of animal behaviour and HCI intersect and contribute towards the embodied work. Technologies in ACI that hold relevance towards the work explored are then examined to investigate how this research adds to the current overall field narrative. At the commencement of the ACI field, and held within this work, these conjoining fields' ethical values came together to reflect the moral and social values of this new field. As this work is ethically situated, these values, and how this thesis aims to delineate from these, will then be examined. Methods used within ACI are then considered with explorations of interaction and intra-action practices drawing from sociology and playful and centring practices. The methods and ethical frameworks lay the foundation of the research methodology and philosophy section that follows the literature. From this, the theories and models currently present in ACI are then investigated from a HCI stance in reflection towards playful and user-centered ACI philosophies. Lastly, previous work done by the author is briefly described and the literature review is concluded through a discussion to establish to the problems that this research aims to address, identifying questions opened through this review and pointing to the chapters that seek to explore these areas.

2.2 What is ACI

The natural question that opens the literature review, and is our starting point, is what is ACI? Superficially, ACI can be defined by its components: the user (animal), the computer and the way they work together (as HCI is defined (Jones, 2016)). It can also be defined, as identified within its early work, by the main goal that it seeks to meet, that being: '*usability through a discussion about factors involved such as constraints, functionally and the user* '(Mancini, 2016). In seeking to differentiate ACI from HCI however, it is important to step back and consider what we define as animal. The Cambridge Dictionary (2016) offers two definitions:

1. Something that lives and moves but is not a human, bird, fish, or insect

2. Anything that lives and moves, including people, birds, etc.

These definitions expose contrasting points of opinion and show two ways of looking at ACI: either as (1) an offshoot of computer science into non-human animals or (2) the encircling of HCI, CCI and other subfields into an overall look at all animals, including humans as animals. Whilst this debate has far-reaching roots back to Darwin's approach in the Origin of Species (1872) it is probably fair to say that it is largely about humans' unique abilities, and beliefs about the uniqueness of species. This latter point has been interpreted differently over time according to the mood of the day and the understanding of mind and action. Descartes wrote in 1660 that *'Animals are mere machines but man stands alone'* but this has been disputed in modern times by animal behaviourists who have challenged human uniqueness in respect of tool use (Reynolds, 2005), gestures (Roberts et al., 2014) and emotions (Brosnan & De Waal, 2003; Lakshminarayanan & Santos, 2008) claiming collectively that animals can do, or have, these attributes. The tension between the two positions challenges ACI to consider methodologically the position that animals hold within the research space. Tattersall describes well the problem space writing that '*We have similarities with everything else in nature; it would be astonishing if we didn't. But we've got to look at the differences',* (Hodgenboom, 2015).

Reflecting on the human-animal difference, the field of ACI emerged in computer science research via HCI but technology had previously been used to explore animal behaviour in other research fields. The inclusion of the term 'computer' in ACI assumes that the technology with which the animal is interacting, or which is facilitating some behaviour, is embedded with computer technology and so is able to react and interact with elements in the environment. The definition of a computer in this sense is an electronic device for storing and processing data according to instructions given to it in a variable program (Oxford Dictionary, 2017).

Interaction, and its study is elemental to HCI and thus also to ACI. Interaction is unpicked in section 1.3.2 of this thesis. The literature on ACI considers Interaction in a broad sense including the dog controlling a system (Britt et al., 2011; Robinson et al., 2014; Zeagler et al., 2016), systems reacting to a dogs' behaviour (Geurtsen et al., 2015; Majikes et al., 2016; Valentin et al., 2015; Mancini et al., 2015) and the dog interacting with the human through its behaviour (Resner, 2001; Lemasson et al., 2015; Morrison et al., 2016; Mealin et al., 2015). ACI is developing as a merger of both animal ethology and psychology joined with computer science grounded within HCI knowledge in a collaborative stance as noted within the ACI manifesto (Mancini, 2011). It is about improving usability of systems as well as creating a meaningful experience for the animal. This is evidenced in work that has studied how dogs can input to technology (Zeagler et al., 2016; Robinson et al., 2014; Mancini et al., 2015), how dogs can be soothed or stimulated by technology (Geurtsen et al., 2015; Zamansky et al., 2015) and how dogs and humans can be connected through technology (Resner, 2001; Lemasson et al., 2015; Morrison et al., 2016; Mealin et al., 2015). An interesting point within these intersections is the transferal of methods, ethics and technologies across species and across disciplines.

From here on in, this thesis will refer to ACI as assuming the exclusion of the human for clarity but will descend from the vantage point of anti-dichotomy within the animal hierarchy by focusing on, like Tattersall (Hodgenboom, 2015), the differences between species' use of computers. It takes a broad view of understanding computer interaction by considering low level questions around the usability of computer technologies, in particular screen based output systems within the context of a research aim that is beyond the scope of the present work which is to enable a dog to have a valuable experience when interacting with a screen based system.

2.3 Technologies in ACI

Technologies that have been explored in ACI include haptic interfaces (Lee et al., 2010; Lemasson et al., 2015; Byrne et al., 2016; Britt et al., 2011; Morrison et al., 2016; Paci et al., 2016; Mealin et al., 2015; Cheok et al., 2001; Valentin et al., 2015; Majikes et al., 2016), olfactory interfaces (Johnston-Wilder et al., 2015; Mancini et al., 2015), inanimate objects (Robinson et al., 2015; Geurtsen et al., 2015; French et al., 2016), screen interfaces (Baskin et al., 2015; Zeagler et al., 2016; Westerlaken & Camiller, 2014; Alfrink et al., 2013) and tracking technologies (Pons et al., 2016; Spink et al., 2011; Webber et al., 2016). The following subsections describe some of these innovations in further detail.

2.3.1 Haptic Technology

Haptic interfaces allow the user interface to be the animal's body sensations, encompassing tactile feedback to perform actions and receive input. One method of instantiating a haptic interface is the use of vibrotactile technologies which can range from skin surface monitoring to vibrating interfaces, as used in Lee et al.'s (2010) early chicken experimentation to remotely stroked chickens. More recently, haptic vibrotactile interfaces have been implemented for dogs, using the same research method as Lee et al. (2010), as a remote vest to stroke dogs (Lemasson et al., 2015). Britt et al. (2011) trained a dog using a vibrotactile haptic interface that responded to GPS, Bryne et al. (2016) used haptic cues to assist in training, an approach also evident in Morrison et al. (2016) who used wearable vibrotactiles to assist in direction pointing in hunting dogs, arguing that vibrotactile input aids the collaborative discussion within hunting between dog and owner. These vibrotactile haptic interfaces, however, have so far only been used within dogs and chickens, who have found a positive reaction to these devices used for pleasure (Lemasson et al., 2015; Lee et al., 2010) and successful training in reported behaviours (Morrison et al., 2016; Bryne et al., 2016; Britt et al., 2011), leaving this UI open for future exploration. Vibrotactiles are not constrained to large animals, in one extreme case vibrotactiles were used with insects (crickets) to play PAC-MAN to investigate if AI is 'funnier' than animals (Cheok et al., 2001).

Biotelemetry devices can be considered as haptic interfaces. These have been used for many years in biological research, playing an important role in the development of behavioural science and in ACI research which looks at the wearability of these devices (Paci et al., 2016). Biotelemetry devices have also been used to inform blind dog owners of real-time heartbeat and respiration rates (Mealin et al., 2015). Mealin et al. (2015) found that vibrotactile interfaces, although they provide more accurate responses, dog handlers prefer to use audio devices. Majikes et al. (2016) used a harness vest system with dogs, like that used by Bryne et al. (2016), Britt (2011) and Lemasson et al. (2015), to monitor a dog's posture during eating, standing, lying, sitting and standing on two legs (Figure 3). Valentin et al. (2015) used an instrumented collar system that monitored head gestures of right reach, left reach and spin and twirl. Whilst they struggled with the sensitivity of such devices, they did find that gesture recognition through collars is viable and pointed to looking to how a dog is trained (i.e. with a leash) to giving an indication of gestures that could be instantiated in such systems.

Figure 3. Posture system used by Majikes et al. (2016)

In the vest system for dogs, Majikes et al. (2016) extended the usefulness of haptic devices by mixing the vest outputs with human analysis for interpretation and finding that this can lead to both a higher rate in successful training. The authors in the future hope to take this device and have cue trained behaviours to allow for more complex behaviours into a fully autonomous system (Majikes et al., 2016).

2.3.2 Dogs Choosing within Technology

In some ACI technologies, rather than the human being in control of the system, the dog is given a choice over the control of technologies. This choice can vary from the dog making simple choices of activating a device (Robinson et al., 2015; Mancini., 2016; Geurtsen et al., 2015) through making choices to sort something (Manicni et al., 2015; Johnston-Wilder et al., 2015) towards less constructed interactions such as interactions with robots (Gregeley et al., 2015).

Johnston-Wilder et al. (2015) (Figure 4) and Mancini et al. (2015) have created interfaces to allow for olfactory detection by dogs using pressure plates. These studies, from Mancini et al. (2015) to Johnston-Wilder et al. (2015), have found that an olfaction system is a possible interaction method within ACI, highlighting the potential of this approach. Currently they are exploring learning algorithms to implement pressure patterns as a recognition tool.

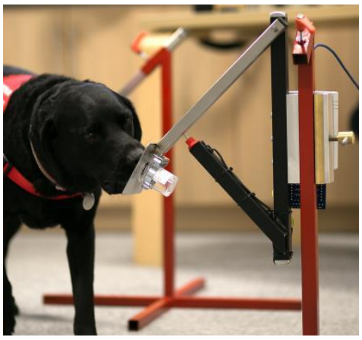

Figure 4. Olfaction cancer detection system (Johnston-Wilder et al., 2015)

In ACI, exploration has also been conducted with inanimate objects such as pulling devices (Robinson et al., 2014), buttons (Geurtsen et al., 2015 [Figure 5]), tree trunks and pulleys (French et al., 2014; French et al., 2016) and robots (Gergely et al., 2013). Robinson et al. (2014) created a pulley system for an assistant dog to call for help, using a tug toy as an interaction mechanism as it is familiar to a dog.

Figure 5. Button system used as a pressure plate to dispense treats (Geurtsen et al., 2015)

Along this same line of thought, French et al. (2016) used ordinary items found within an elephant's enclosure to allow the automatic use of devices such as a shower. Geurtsen et al. (2015) used a more human-like method for dogs; they used a pressure plate button to give the dog a treat in line with current consumer products for dogs such as CleverPet (2016). Gergely et al. (2015) further examined interaction with unidentified moving objects (UMO) by investigating how dogs act socially with robots. Gergeley et al. (2015) found that dogs act socially towards UMOs form expectations of the system over a short period offering up an indication towards social robots for dogs. Likewise, Sigh & Yong (2013) used robotic tails on robots which could move positions (wag, raise, lower and hold straight) to investigate the tail communication states, but they have yet to test this method with other dogs to draw conclusive results.

2.3.4 Screen Technology

Whilst diverse interface devices are used in ACI visual and touchscreen interfaces form a large proportion of animal-computer research. Research in this area has been conducted using tablets as UI in dogs for videos (Baskin et al., 2015), Zeagler et al., 2016 [Figure 6]) screens for remote notification systems, games for cats (Westerlaken & Camilleri, 2014) and orangutans (Webber et al., 2016 [Figure 7]) and wall interactive devices for pigs (Alfrink et al., 2013).

Figure 6. Dog training to click on points on a touchscreen interface (Zeagler et al., 2016)

Screens can be configured solely as output technologies or, more recently, as input / output using a stylus or touch. Orangutans have been shown to be able to use visual touchscreen interfaces with a stylus (Ritvo et al., 2014) to control a music player. Zeagler et al. (2014) examined touchscreen interfaces with dogs for an alert interface and pointed out that affordances should be investigated to make touchscreens more usable for dogs i.e. colour and space between activation 'dots'. More recently, Zeagler et al. (2016) presented work around the training methods of implementing these systems with dogs using touchscreen (nose) interfaces. Zeagler et al. (2016) sought to train dogs to connect two dots on a touch screen interface by firstly training a dog to touch a single dot and then training the dog to slide the nose between two dots. Their work presented guidelines for future touch screen interfaces around the type of interfaces (non-projection monitors), the target distance and size (at least 3.5 inches) and on the best training paradigms (shaping for training touch and backchaining for sequential tasks) towards getting dogs to achieve the best behaviour modification required to use the technology. Importantly, Zeagler et al.'s (2016) work found that first contact touch screen interfaces are easier for dogs to use and understand than lift-off interactions adding towards the design considerations and training methods in the space of dog screen interfaces. Zeagler et al. (2015) seek to further explore this space through fully training dogs to use such screen systems to 'call for help'.

Figure 7. Apps for Apes: An orangutan using a touchscreen (Webber et al., 2016)

Whilst touchscreen design is clearly interesting, ACI has still not really understood to what extent an animal, and in particular specific animals, attend to screen based displays. Dogs' attention to screens has been previously explored in studies in animal behaviour that have tracked vision with static images (Somppi et al., 2012; Williams et al., 2011 [Figure 8]). Extending this study into moving media is beginning to be explored within ACI through workaround screen interaction with artificial presences and virtual reality systems (Ohta et al., 2016). Ohta et al. (2016) work in progress research plans to use interactive videos interfaces to investigate the visual feedback loop (with partial depth cue perceptions) effect on animals' behaviour to investigate the animal attachment between dogs and robots. This research builds on Miklosi et al. (2015) previous work on visual communitive signals between dogs and humans and cats and humans and Pongracz et al. (2003) work on projecting human images to signal dogs. There is therefore, a growing nonetheless limited body of research, as demonstrated above, to investigate and map an animals' requirements, in this case dogs, towards visual interfaces. One way requirement and evaluations have been conducted with visual interfaces in HCI and animal-technologies is through tracking technologies.

2.3.5 Tracking Technologies

The notion of eye tracking has been around since the 1800s where people conducted eye movement studies from observations with Edmud Huey progressing the field in 1908 using contact lenses on the subject's eye with a hole for the pupil and the use of aluminium pointers (Campion, 2017). Moving the field forward, towards building non-intrusive eye tracking technology, Guy Buswell in 1937 used light beams reflected off the reader's eyes and recorded these movements on film. These early eye trackers were surrounded by initial theory in the 1950s and 1960s on eye movement and fixations giving insight towards the user's interests. The research around eye tracking progressed then further in the 1970s and 1980s with improved accuracies with Cornsweet and Crane (1973) separating eye movement from head movement. This grew psychological theories building on the connection of fixation and interest towards linking eye movement and cognitive processes.

As computer technology progressed in the 1980s, real-time tracking video-based (non-contact) technologies became popular in HCI. In the late 1990s companies started using these tracking technologies towards observing reactions to internet content in an aim to quantify a user's experience. These novel uses of eye trackers has continually evolved to help provide insights in HCI towards human behaviour. This has branched out to position technology as a communication mechanism, in ophthalmology for health, usability testing and linking HCI towards cognitive, perceptual and social abilities through various age ranges. This has been particularly important in tracking movements to understand display-based and visual information processing impacting upon the usability of a system interface (Poole & Ball, 2006). The average accuracy of modern day eye trackers falls within the range of between 0.5 and 1 degree (Bojko, 2011).

In the late 1990s early 2000s, eye tracking technology was expanded towards animal users, focusing mostly on primates and dogs; some of this work involved surgical interventions (Gothard et al., 2004; Nahm & Amaral, 1997; Watson et al., 2009). Body, face, eye and gaze positioning have played a part in understanding human and animal behaviour in ACI through tracking gaze (Somppi et al., 2012), body posture (Pons et al., 2014; Mealin et al., 2017) and automated face reactions (Leach et al., 2012) similarly to HCI (Jacob & Karn, 2003; Pool & Ball, 2006). The advancements made in HCI tracking technology have not yet been fully exploited in ACI technologies, but there have been a few attempts to track animals. North et al. (2015) proposed an ACI tracking system for horses, Pons et al. (2014) proposed one for cats with Willaims et al. (2011) and Somppi et al. (2012) one for dogs (Mealin et al., 2016).

Williams et al. (2011) wanted to increase spatial accuracy for laboratory settings by using mobile head mounted, video based, eye-tracking stem within an accuracy of 2-3º. They used a singular dog, a male Alaskan Malamute, ages two years (seen in Figure 8) and tracked him watching dog treats. Williams et al.'s (2011) system could provide a great level of accuracy (2-3º), after training the dog, of an eye-tracking system than previous systems such as the 5-10 º found by Shepard & Platt (2006) in a more naturalistic setting, albeit still in a laboratory.

Sompii et al. (2012) took a different approach than Williams et al. (2011), both seeking visual cognition, by instead of training a dog to wear a mounted system, trained a dog to rest its head upon a headrest to achieve contact-free eye movement tracking. Unlike Williams et al. (2011) Sompii et al. (2012) used pictures rather than treat location tracking. Sompii et al. (2012) used six dogs five female and one male, three Beuce Shepards, a Rough Collie, a Hovawart and a Great Pyrenes varying in ages from 1-5 years. Sompii et al. (2012) research provided evidence that dogs focus their attention on informative regions of the images where their gaze fixation depended upon the images category (human, dog, shape and letter). This discrimination of images lead to suggestions that dogs can discriminate images of different categories corresponding with Fargo et al. (2012) who found that dogs consider natural objects more interesting than abstract ones. Somppi et al. (2012) did comment however, that they cannot yet draw any conclusions as to whether the attention of dogs was directed towards stimulus features or sematic information or a mixture of both opening up questions in dog tracking around the impact of the complexity/simplicity of the image in regard to findings. This work did delineate towards species-dependant behaviour (Guo et al., 2009; Racca et al., 2012) when viewing faces towards a more natural setting moving Williams et al. (2011) goal of naturalistic tracking forward.

Recently Mealin et al. (2016) has stepped away from eye-tracking towards movement tracking in dogs building from Pons et al. (2015) work on Microsoft Kinect infrared tracking towards completely passive off-body sensing to reduce animal stress. Mealin et al. (2016) aims towards posture and behaviour recognition detection and classification from static images within the boundaries of "standing", "sitting" and "lying" postures. Mealin et al. (2016) system used recordings of five dogs, three Labradors, a Shiba

Inu and a Kai Ken, varying between the given postures. Their systems algorithm identified lying posture within 92.2%, standing within 69.5% and sitting within 69.3%. They were able to attribute much of the low accuracy to the Kai Ken dog which was hard to track, and reported a 5% increase in overall accuracy with this dog's omission. Mealin et al. (2016) plan to move their work forward by developing further model-parameter learning algorithms suggesting its use towards training algorithms (Mealin et al., 2017).

As outlined above, therefore, animals can be trained to use tracking systems (Somppi et al., 2012) or can be tracked wearing head-mounted systems (Williams et al., 2011), but both these strategies are known to influence their ordinary behaviour, which researchers are typically aiming to measure.

The limited work that has been done to date has helped researchers in allowing animals to indicate choices visually thus giving an insight into their cognition, vision and social interactions (Williams et al., 2011; Crutcher et al., 2009). This visual-cognitive gaze direction towards important and informative objects affects various cognitive processes (Henderson, 2003). This research into animals' cognitive processing of technology is particularly needed in animals where welfare is of concern because they cannot vocalise opinions and choices. Tracking attention may be used to monitor pain thus preventing bad practice (Leach et al., 2012; Mintline et al., 2012).

From behavioural observations with dogs and screens, dogs have been shown to attend to two-dimensional images and perform visual tasks (Range et al., 2008). Dogs observing screens are reported being able to correlate photos and voices of their owners from screen media and able to distinguish facial images between two images of dogs and humans (Racca et al., 2010). This provides evidence in research that dogs, whilst they do not view screens the same as human users, can distinguish and identify objects on screen-based technologies.

Figure 8. Using a head-mounted, eye-tracking system with dogs (Williams et al., 2011)

Understanding attention of dogs to screens is often measured manually through orientation behaviour (Adaci et al., 2007; Racca et al., 2010; Guo et al., 2009; Farago et al., 2010). When a dog faces towards a screen, this could include both active and blank stares. Somppi et al. (2012) and William et al. (2011) aimed to discriminate between active and blank stares by using eye-tracking to directly assess gazing behaviour. Whilst these methods are successful, Somppi et al.'s (2012) method required a dog to be trained in the direction of the screen influencing the data collected as the dog was unable to look away. Williams et al.

(2011) required a dog to wear a head-mounted system (Figure 8), which did not allow the dog to move his head in a natural way. These systems, whilst workable, do not allow a dog to behave normally either requiring a behaviour modification or training to use the required system.

These constraints and difficulties of tracking technologies leave a space open within animal-computing to draw back to the original observational tracking methods in HCI to allow dogs to explore technology in ordinary ways, merging early human methods with current usability methods. ACI has recently has proposed image-based-human-interpreted recognition systems with horses (North et al., 2015), orangutans (Webber., 2016), cats (Pons et al., 2015 [Figure 9]) and dogs (Mealin et al., 2016; Mealin et al., 2017).

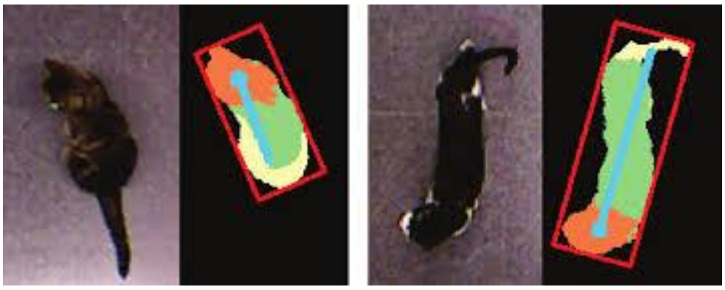

Figure 9. Tracking cats using depth measurement via an Xbox Kinect to detect posture (Pons et al., 2015)

These systems vary in how they operate using image shape recognition (Pons et al., 2015; Spink et al., 2011) feature and posture recognition (Pons et al., 2015; Mealin et al., 2016; North et al., 2015), motion recognition (Webber et al., 2016) and point recognition (Williams et al., 2011; Somppi et al., 2012). In dogs as explained above, Williams et al., 2011 and Somppi et al., 2012 both use finite eye-tracking recognition but require significant modification of the dogs' behaviour using eye reflections. Mealin et al. (2016 [Figure 10]) use posture and feature recognition paralleling Pons et al. (2015) work on cats. Mealin et al. (2016) use average depth values and aspect ratios of bounding boxes around the animal rather than clustering features for classification as conducted in Pons et al. (2015) work.

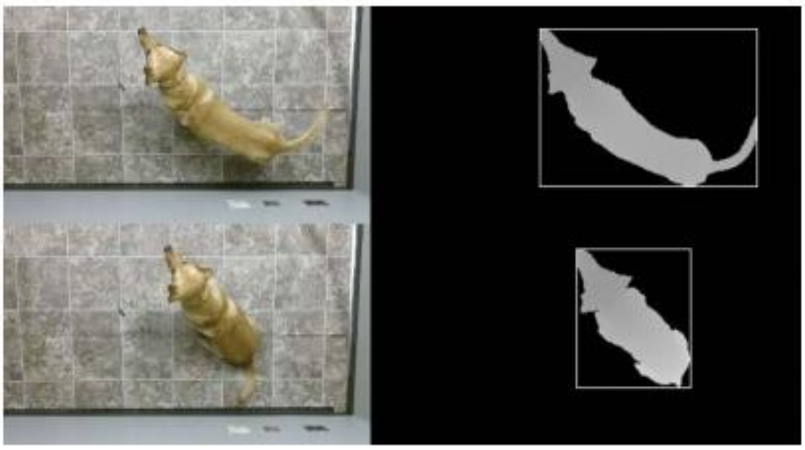

Figure 10: Tracking dogs using posture recognition via an Xbox Kinect (Mealin et al., 2016)

These systems however are still semi supervised where, in the case of Mealin et al. (2016) multiple images of the background must be included within the training data set to gather better depth reading when comparing singular images, simplifying background separation from the dog. This requires an expert user to implement this system. In this way, the space for tracking dogs, and specifically tracking dogs using screens, is sparse but growing towards untrained and unsupervised off-body systems.

From this review, it seems that whilst eye-tracking technology has uses in ACI and while image and posture recognition can be useful, there is still much needs to be done to ensure its usefulness and naturalness. Specifically built animal contact-free and training-free versions of eye tracking systems do not exist. There is clearly a space open within dog-computing for a method to track a dogs' attention whilst using screens that is both friendly towards the dog and methodologically appropriate.

2.3.6 Technology in the Home for Dogs

Whilst technology has long been used with dogs, the role of dogs within society varies. There are working dogs as used in hunting, controlling rodents, helping fishermen with nets, and doing search and rescue and guarding. Service dogs include guide dogs and assistant dogs. Dogs are also known to be good companions with there being over 8.5 million pet dogs in the UK (RSPCA, 2015). Within homes, dogs find themselves in technology rich situations in which they co-evolve with humans; Paul Bloom quotes "Dogs, are the next chimpanzees" (Horowitz, 2014. P4).

The role a dog held within technology shifted with Resners' (2001) work on Rover@Home where he began to think about dogs and technology in terms of interaction design and the different motivational, cognitive, perceptual and motor abilities of the dog. Resner (2001) sought to connect the dog to the owner through technology flipping the traditional paradigm of using technology to explore a dogs' cognition and behaviour for human purposes, to using technology to enhance a dogs' welfare and improve or develop the human-animal bond. As ACI currently stands, dogs are the most researched animal within its publications, however these studies still mostly focus on either training methods (Zeagler et al., 2016) or assistance technologies (Robinson et al., 2014; Mancini et al., 2017; Morrison et al., 2017) with little or no research being conducted for dogs within their own homes.

Home is where most dogs in the UK spend most of their time. Of the 8.5 million dogs, 2.3 million are routinely left in solitude for five or more hours and this is thought to be harmful to their wellbeing (PDSA, 2017). Whilst ACI began by exploring technology for service dogs there is a tangible initiative for ACI to be implemented within the dog's own home, and to develop methods on how to do so. The pet industry has noted this gap in technology for home-alone pets and has recently flooded the market with pet cameras such as PetCube, cognitive toys such as Cleverpet, robotic balls such as Sphero, automatic treat feeders and a whole TV channel for dogs. However, there has not yet been research conducted on how to implement and design these technologies in a methodological way with support of the owners within the dogs own home.

2.4 Ethical Considerations in ACI

The development of technologies for dogs requires the consideration of the ethics of both the innovations and methods implemented. The oxford dictionary defines ethics as a set of:

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'Moral principles that govern a person's behaviour or the conducting of an activity' (Oxford Dictionaries, 2017).

Ethical norms are learned through social settings and are often acquired during childhood developing throughout life as a person matures (Resnik, 2015). These norms are applied, interpreted and balanced in different ways towards a person's own values and life experiences imbedded within the societal legal rules that govern behaviour (Resnik, 2015). Within research, ethics can be defined as the method, procedure or perspective on deciding how to act and deal with problems often in a cost and benefit scenario (Resknik, 2015).

Ethics in research has become a cornerstone of modern scientific research originating in the 1940s focusing on responsible research conduct, the documentation and reporting of the research and the treatment of human participants (Wright, 2006). Ethical requirements for computer science were driven forward with the world's first computer crime and the realisation that there were no laws against this behaviour (Learning Computing History, 2001). This lead in 1973, to the Association for Computing Machinery (ACM) to adopt its own code of ethics and for governments in Europe and the United States to implement computer crime and privacy laws (Bynum, 2011). These ethical standards have since branched out into various national and international societies and organisations, such as British Computer Society (BCS) and IEEE, giving behavioural guidelines towards both the researchers that conduct work and the users of these machines. The ACM rules have since been replaced by ethical rules coined "ACM code of Ethics and Professional Conduct" consisting of 24 statements of personal responsibility for researchers (ACM, 2017).

There is a distinction between what is ethical and legal, broadly speaking in HCI the current ethical and legal frameworks for the protection of human participants rely on the principles of autonomy, beneficence and justice (Frankel & Siang, 1999). Autonomy requires consent and that those with diminished abilities have protection, beneficence seeks to maximize the benefits whilst reducing the harm and risks, with justice seeking a fair distribution of these benefits and burdens towards equal proportionate risks (Frankel & Siang, 1999).

Animal science has long been used to advance both the science and medical fields throughout the past century. However, the use of animals within science and medical research has encouraged animal-rights extremists to decry animal use within these settings as cruel and unnecessary; possibly disregarding the purpose or benefit (Festing & Wilkinson, 2007). As a result, there is an increased ethical awareness of animal researchers and animal cognition to conduct research within an ethical framework (Festing & Wilkinson, 2007). Early animal ethics appeared in 1959 written by R.L Burch and W.M.S. Russell for animals in testing with the Three Rs (3Rs) approach of replacement, reduction and refinement. In the 1970s and 1980s the living conditions of animals used within experimentation became a social debate calling for researchers to recognise the intrinsic value of the animal (van der Tuuk, 1999). This drive towards recognising an animals value beyond the mechanical features has hinged upon the animal's ability to be a sentient being conscious of the positive and negative experiences that the animal has whilst under research. Ethical frameworks for animals have evolved in the UK, which holds the most advanced ethical frameworks for animals written into law through the Animals (Scientific Procedures) Act 1986 which incidentally exceeds the European Union's Directive 86/609/EEC on the protection of animals used in experiments and science (Matthiessen et al., 2003). Part of this act, like the ethical frameworks in HCI, requires the potential benefits of the project to be weighed against the procedures, number and type of animal used in a cost vs. harm scenario.

The issue surrounding the ethical implementations of making products for animals was highlighted in Lawson et al.'s (2005) research on speculative technology (they used the term 'upstream') where they found that the scientific basis of technology was unimportant to animal owners, potentially exacerbating existing human-animal problems. Products can also be advertised as having benefits without there being research to back this up. For instance, CleverPet claims to use software to detect social anxiety in dogs (Hirskyj-Douglas & Pons, 2015) despite there being no scientific evidence behind this. Ethics in ACI therefore is also an embodiment of the research methods, towards the way we as research use, and design, animal-technologies.

In ACI, ethics has been considered through early guidelines for conducting HCI studies with animals (Väätäjä & Personene, 2013) as well as through general ACI frameworks which take a welfare-centric approach to support ACI development (Mancini, 2016). Whilst these works all have an underlying theme of welfare at the centre of the ethical approach they differ in their defining criteria, with Väätäjä & Personene (2013) taking the traditional 3Rs approach and Mancini (2016) focusing on mediated and contingent consent drawing from the principles of autonomy and justice (Frankel & Siang, 1999). The application of ideas is still in its infancy in ACI however with there being no current clarity on how to empower dogs as active users, comparable to the liberties afforded towards humans for ethics in computer science. The ethical protocols currently existing in animal behaviour need to be advanced and questioned towards animal-technologies to make sure that the research being undertaken is both morally and socially ethical and lawful.

2.4.1 Emotions Held within Non-Human Animals

In discussing ethical protocols, the animals' rights are associated with the ability the animal has to 'feel' emotions which draw at the need for the ethical protocols. Recently, research in animal behaviour and cognitive science is demonstrating that emotive states, previously only attributed to humans, are evident within animals. Early research was quite anecdotal and lacked scientific approaches but recently behavioural data, seeing how animals adapt, has been acknowledged as a method for study (Dawins, 2000). Scientific approaches can include understanding the human role towards animals (Oatley & Jenkins, 1996); studies of the similarities that drive animals (Paul et al., 2005); cognitive bias testing, where patterns of deviation within judgement in situations are used as an indicator (Haselton et al., 2005); psychoactive drugs to test affect (Sherwin & Ollson, 2004) and neuron functions (Hof & Van Der Gucht, 2007), vocalisation (Boissy et al., 2007) and behaviour (Mendl & Paul, 2004).

These methods suggest behavioural attributes in numerous studied animals, mostly in primates, rodents, horses, birds, dogs, bees, fish and cats. Primates are seen to experience empathy and theory of mind (Winford, 2007) along with rodents (Longford et al., 2006) and birds (Orlaith & Bugnyar, 2012). Cats have been known to use manipulation (Live Science, 2009) whilst bees have been shown to have pessimistic cognitive biases similar to rats and dogs (Bateson et al., 2011). Fish have displayed fearfulness and anxiety (Sneddon, 2015). Horses and primates were shown to react differently towards different human facial expressions (Smith et al., 2016), giving induction to perceiving emotions. This is taken further in dogs who, like primates, have a non-symmetrical right bias gaze (Guo et al., 2007) and this has been used to identify emotional states between dog-human interactions. Dogs have been shown to have personality traits, such as playfulness, curiosity/fearlessness, chase-proneness, sociability and aggressiveness, shyness and boldness (Albuquerque et al., 2016).

This exploration into animal emotions is an evolving landscape, and whilst research explores animal cognition into further depth, the definitions of what animals 'feel' blurs boundaries to what it means to be an animal and helps assess the impact of animal-technology systems upon animal states. It is within this stance that animal emotions have are directly impact animal-computing in a very real sense towards quantifying the animals' experiences and thus actions. This thesis does not aim to investigate proving and disproving animal emotions, instead choosing to rely upon current literature knowledge reporting the owners' own interpretations, but does lay out a research and ethical approach towards working towards animal empowerment considering both the ethical protocols and animal cognition.

2.5 Methodological Approaches to ACI

2.5.1 Scientific Enquiry

Scientific methods are a logical schema used by researchers to seek answers for the questions posed within science (Dodig-Crnkovic, 2002). In computer science, these methods are required to implement technological systems and reflect on the embodied ethical considerations. Computer science methods draw and utilise concepts from various disciplines, including logic and mathematics, natural and social sciences and humanities, integrating theory and practice, abstraction and design specific (Dodig-Crnkovic, 2002). These methods created are then used to produce scientific theories, meta theories (theories on theories) and theories for tools to produce theories (algorithms etc.) (Dodig-Crnkovic, 2002).

2.5.2 Research Methods in Computer Science

Typically, as proposed by Dodig-Crnkovic (2002), the scientific method suggests a five-step process: 1) posing the research question within context, 2) formulating a hypothesis, 3) deducing consequences and making predictions, 4) testing the hypothesis in a specific experiment/theory, 5) proposing a theory; after consistency is obtained a hypothesis becomes a theory providing a set of propositions that define a new phenomenon or concept. This process is often recursive with new equipment and methods being designed often used as a tool to test these hypotheses matching the results against the design specifications. In this way, scientific methods in computer science are not a concrete set of rules but an evolving space of repetition and exploration into new technologies and application of methods meaning that scientific truths are provisional (Dodig-Crnkovic, 2002). These provisional truths are intercorrelations between research, science, technology and development as shown in Dodig-Crnkovics (2002) model (Figure 11).

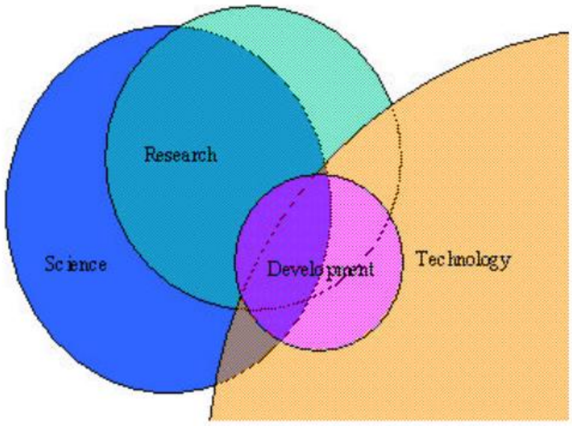


Figure 11: Relationship between science, research, development and technology as proposed by Dodig-Crnkovics (2002; Figure 3).

The computer (physical object related to theory) within this form of method research is then not the focus of investigation but rather theory materialized as a changeable tool to accommodate more powerful theoretical concepts (Dodig-Crnkovics, 2002).

2.5.3 Research Methods in HCI

Research methods in the multidisciplinary area of HCI have been a keen area of investigations (Zimmerman et al., 2007; Cox et al., 2008; Millen, 2000; Lazar et al., 2017). HCI research uses both experimental research and design using approaches such as surveys, diaries, case studies, interviews and focus groups for ethnographic, usability testing, automated systems in qualitative and quantitative comportments (Lazar et al., 2017). These methods are often adopted from aligned communities (engineering, design, science) drawing on existing knowledge (Cairns & Cox, 2008). The method used depends on what the researcher hopes to learn or accomplish towards their goals within four areas: 1) evaluation or comparison, 2) invention or design of a new system or features, 3) discovering and testing and 4) establishing guidelines and standards (Landauer, 1988). This method formation therefore inherently involves both what kind of information to obtain and how to obtain this data in an accurate, unbiased and efficient schema (Landauer, 1988). For these methods to be transferable, the method must be designed for the specific set of users to be able to give the same results as those that would use the system for real maximising the results towards being effective, practical and appropriate (Laundauer, 1988). A suggested approach is to use a combination of methods to strengthen the research in both qualitative and quantitative analysis to strengthen the issues faced within both paradigms (Cairns & Cox, 2008).

For design, one method used in HCI originating from the 1990s is the use of personas. This was developed from IT systems development towards various concepts including marketing, products, planning communication and service design (Nielsen, 2017). It is commonly derived that a persona is a description of a fictitious user either based on data or assumptions (Nielsen, 2017). In this way, personas are archetypical resemblances of a user profile of a real or potential user (Blomkvist, 2002). These personas show patterns of the system users' behaviours, goals, motives and information needs, all merged into a single fictional description of a user (Blomkvist, 2002). With a history in marketing (Moore, 1991), personas were introduced by Cooper (1999) into product design with the aim to fight the then common problem of communicating the distinct current user to the development team. Cooper (1999) suggested that the creation of a persona should be loosely based upon interviews and observations, introducing what is latterly referred to as a goal-directed perspective. With this approach, there was no real thrust to find representative users (Sinha, 2003). Cooper et al. (2014) more recently updated his approach to emphasise the need for performing qualitative research, suggesting basing personas on interviews and observations, but also mentioning possible sources of market research data (such as focus groups and surveys) or market-segmentation models. Later, contrasting this, to make personas, Grudin & Pruitt (2002) used quantitative and qualitative information to find the representative user; this approach is being referred to as taking a role perspective. Grudin & Pruitt (2002) used methods such as market and field studies and focus groups to inform their persona-creation process. Leading on from this, there is also the engaging perspective which is rooted in the ability of the stories told by the persona set to generate and secure involvement and insight (Nielsen, 2016). This perspective aims to avoid stereotypical users by involving the designer in the lives of the persona (Nielsen, 2016). Lastly, there are fictional-based personas which unlike the previous persona methods do not include data as the basis for persona description (Nielsen, 2016). Instead, this method uses the designers' intuition and assumptions.

An empirical method for HCI is usability evaluation using an observational method which involves the researcher viewing the users as they work in a field study (Preece et al., 1994). Observational studies have long been conducted within psychology for user research migrating over to HCI as a tool to automate the process (Shneiderman & Plaisant, 2006), methodologically (Rieman, 1993) and as a framework (Mackay & Fayard, 1997). These observations can either be direct, where the observer is present during the task, or indirect, through video recording or other means (Preece et al., 1994). This method allows for qualitative data and is useful for studying currently executed tasks and processes as it allows the observer to see what the users do in context (Preece et al., 1994). It is noted however, that the user may change their behaviour with the presence of the observer, coined the Hawthorn effect, and so often indirect method is chosen with the users' co-operation being vital (Preece et al., 1994; Hogue, 2017). There are two types of observational methods; controlled and naturalistic. Controlled observations often take place within a laboratory environment and focus on quantitative data, although may yield qualitative observations (Hogue, 2017). These controlled observations often require users to carry out a series of tasks and require the researcher to explain the purpose of the observation to the user with the researcher often there (Hogue, 2017). The advantage of this method is that the study is easy to reproduce, quick to conduct and analyse as it harvests quantitative results but is mitigated by the Hawthorne effect. Naturalistic observations involve "in the wild" studies of the user which are often less structured than within a lab environment where the researcher often spends time with a user or a group of users observing their normal behaviour in day-to-day life (Hogue, 2017). Whilst this method does produce more reliable results which are useful for ideation opening the qualitative findings towards further possibilities than a controlled environment it can be difficult to include a representative sample that is replicable whilst recording all variables (Hogue, 2017).

A limitation of observational studies is the extent to which an observer can 'interpret' behaviours (Bannon, 1991). Where the context of observation is complex, it is often necessary for observers to be trained to be effective at both looking at what they see but also in determining what is meant.

2.5.4 HCI Applied to ACI

ACI has taken methods from computer science, HCI and animal science to involve animals within the research space. This building of methodology resources is no different than the beginning of other disciplines, but does tell a story on adaptation. Whilst these methods are mostly focused on pet users such as dogs (Byrne et al., 2016; Nelson & Shih, 2016; Majikes et al., 2016) and cats (Pons et al., 2014; Westerlaken & Gualeni., 2014) they also have evolved from studies with zoo and captive animals (French et al., 2016; Webber et al., 2016) and free roaming animals (Aspling & Juhlin, 2016; Kobayashi et al., 2015). The methods used in ACI include case studies, field studies, action research, lab experiments, survey research, applied research, basic research and normative writings to help understand, engineer, re-engineer, evaluate and describe phenomena.

2.5.5 Research Methods Used in ACI

Methods used in ACI include algorithmic case studies (Winter et al., 2016; Pons et al., 2014; North et al., 2015; Majikes et al., 2016; Kays et al., 2011; Gomez-Marin et al., 2012) usability evaluation case studies with screens (Ritvio et al., 2014; Westerlaken & Gualeni, 2014; Wirman, 2014) and naturalistic interfaces (Kobayashi et al., 2015; Johnston-Wilder et al., 2015), field observational studies (Baskin et al., 2015; Mancini et al., 2015; Paci et al., 2016; French et al., 2016), lab preference experiments (Gergely et al., 2014), personas (Robinson et al., 2014), geotagging proposals (Micklin et al., 2014), gesture recognition laboratory studies (Valentin et al., 2015), design fiction (Lawson et al., 2014), suitability user testing (Alcaidinho et al., 2014), biological markers comparison (Geurtsen et al., 2015) and surveys for human valuation (Carter et al., 2015; Baskin et al., 2015; Robinson et al., 2014; Nelson et al., 2016).

One of the main challenge faced within ACI methods is the evaluation and requirement gathering from a non-verbal non-literate user as most HCI and computer science methods require written or spoken communication as is seen in cognitive walkthroughs and in survey. This is mitigated in ACI through using the animals' biological system (Geurtsen et al., 2015), capturing human judgement through the animals' carer or owner and behaviourists interpretation in surveys and interviews (Baskin et al., 2015), with the use of observations (Mancini, 2016) and by training animals to use human systems to draw requirements from the training paradigms (Zeagler et al., 2016).

Observational studies have long been used in animal science as a method to understand animal behaviour, often within their natural environment in contraposition to experimental research where "artificial" behaviours are present (Vicedo-Castello, 2017). These natural observations are a method to collect data from the animal without the subjectivity of the observer through alternative sources such as video recordings (Vice-Castello, 2017). This however, does mean that the treatment that each subject receives to some extent is beyond the control of the investigator. ACI has taken this method used in animal science for behaviour and merged this method with HCIs evaluation techniques to create the field's own method of observational analysis towards technologies. An example of this includes Paci et al. (2016)'s observational analysis of cats' behaviour using various tracking collars.

As important as the observation, and debated within animal science and behaviour, is the setting in which the method is conducted; either in an artificial setting such as a laboratory or in the animals' normal natural homes. Laboratory tests are important for studying animal behaviour as they provide a method of isolating the variables having complete control over the environment. Yet, field experiments in an animal's normal environment provide authentic results but have little control over the impacting variables. These field studies can also be potentially disruptive to the subjects and ecosystem (Nisbet 2000; de la Torre et al. 2000; Williams et al. 2002) creating interference with the proposition that the study aims to investigate through a change of behaviour (Martin & Bateson 1993). However, in ethology, usually the focus is to study an animal's behaviour under natural conditions (Marriam, 2017) whilst in HCI, it is often recommended to combine both artificial and field studies to ensure external and internal validity through shared occurrences (Sun & May, 2012). Whilst there is extensive literature on how to observe a dog's behaviour in laboratory settings (Hasen, 2003; Quinn et al., 2007) with technology (Zeagler et al., 2016; Gergely et al., 2014) there is currently no method in ACI to study a dog's behaviour using the observational method within the dog's own home. Such methods could provide the wider generalisability of results from laboratory to field settings, as has been conducted within HCI and animal behaviour.

Part of this observational method is not only to consider the setting but the description and interpretation of the captured behavioural data. Animal gestures, postures and sounds, convey meaning to other animals and the environment as a form of communication (Broom & Fraser, 2015). These displayed behaviours in ethology have traditionally been classified by a response to stimuli or a trained behaviour in a laboratory context (Broom & Fraser, 2015). ACI's intersect between ethology and technology leaves a space open towards classifying traditionally seen dog behaviour in trained behaviour situations as researched by Zeagler et al. (2016) Mancini et al. (2016) and Gergely et al. (2014) or towards a response stimuli as investigated by Zamansky et al. (2016) in computer science situations.

As technology for animals develops within this design and interaction focused ACI area, there is a gap of knowledge and a requirement to examine methods on how to observe and quantify dogs use of technology within the home field situations from a dog's ordinary response to build up methods organically from the dog. By collecting a dog's response towards stimuli, within the field study environment, this could begin to build up methods for collecting and quantifying a dogs' interactions with technology strengthening the ACI field, and thus the adjoining areas of HCI and ethology.

2.6 Theories, Models and Frameworks within ACI

In computer science, the method, ethical and technological considerations are reflected through the theories and models formed. Models are a simplification of reality aiming to be useful, descriptive, predictive and generative (Beaudouin-Lafon, 2017). Theories attempt to explain reality and are typically built from models through experimentation (Beaudouin-Lafon, 2017). Models and theories evolve with the computerised systems progression blending software engineering and human factors towards more human-centric computer interaction design (Lynn, 2011).

2.6.1 Theories in HCI

Many HCI theories have their basis in ergonomics of human biology. Examples include the ecological theory of perception (McArther & Baron, 1983), Hick's (Hymen, 1953) and Fitts' law (Fitts, 1954) and kinematic chain theory (Pavlovic et al., 1997). Other theories are more from psychology and behavioural science including action theory (Norman & Shallice, 1986) and activity theory (Bertelsen & Bodker, 2003). Theories that can be clearly associated to HCI and interaction include morphological analysis of input devices (Card et al., 1991) and instrumental interaction (Beudoin-Lafon, 2000). Some theories, for example Fitts' Law, have been widely adopted by the HCI community and are now extended some distance into areas for which they were not initially intended (MacKenzie, 1992)

2.6.2 Playful Interaction Theory in ACI

Theories on playful interaction has become an important topic within HCI research, particularly in CCI, where there is an ongoing debate on the fundamental principles that underpin playful systems (Egglestone et al., 2011). Within ACI, a trend has grown to step away from traditional working environments towards playful scenarios driven by play being the most natural and inherent behaviour in the majority of living species (Pons et al., 2015; Huizinga, 1985). Playful ACI aims to take steps to electrify play through computer ecosystems to provide natural enjoyable interactions in a similar ludic revolution that has been provided for humans (Pons et al., 2015). Playful ACI interactions have been shaped around frameworks such as Intelligent Playful Environments for Animals (IPE4A) (Pons et al., 2015) which has requirements and features for future intelligent environments (Figure 12) and digitally complemented zoomorphism (Westerlaken & Gualeni, 2013) which aim to structure playful environments through requirements and features.

Requirements	Features
Playfulness	Number of participants
Intelligence	Participants' species
Reactivity and interaction	Human participation
Animal-centered design	Human presence
	Control
	Information acquisition
	Learning inputs
	Types of stimuli
	Single-purpose vs. multi-purpose activities

Figure 12: Pons et al. (2015). Table 1. Requirements and features of future intelligent playful environments for animals.

This theory is relatively new within ACI, and there is still a missing gap within the implementation phase of how to implement these components however the core requirement of Animal-Centred design encourages the community to consider how this can be effectively included.

2.6.3 User-Centered Design in ACI

User-centered design is a prominent framework within HCI and is one in which the usability goals, users' characteristics, tasks and workflow of a product, service or process and the environment are given attention at various stages of the design process. User centered design, originating with the formative work of Norman and Draper (1986), involves designers looking at both how the user consumes the product but also to test these assumptions in research to allow development to proceed with, and optimize, a user centered focus (W3, 2017). This process is about changing the product around the users' requirements rather than, as done traditionally in computer science, changing the users' behaviour to accommodate the product (W3, 2017). User centered design is massively used in HCI including as agile systems (Hussian et al., 2009), virtual environments (Gabbard et al., 1999), CCI (Markopoulous & Bekker, 2003) and games (Pagulayan et al., 2002).

Following this trend, ACI has also adopted user centred design to put the focus on the animal within the interaction. This concept in ACI was first explored in the ACI Manifesto by (Mancini, 2011) who referred to animal-centred interaction. ACI centring practices are important to allow systems to be shaped fully around animals' needs and preferences, deriving ordinary results from a system that is made for animals. This acknowledgement and respect of animals within ACI systems is tied into ethical considerations (Mancini, 2011) through the treatment of the user within the system, theory or process. However, whilst there is a movement towards user centric design in ACI the implementation of this practice towards an animal user, particularly those that are 'owned' such as pets, is still needing work. Gathering requirements from animals is a first step that needs attention in ACI. Within HCI, humans are involved within systems as users, theorists and designers. Thus, systems are designed in such a way that symmetric meaning can be derived equally from these various vantage points. In ACI the meaning derived from the animal of a system is unknown, leading to asymmetry. This same interaction meaning can be seen within animal-human relationships where, through learned and experienced behaviour, the operators fashion their own communication language, what Haraway (2008) termed as 'becoming with':

'If we appreciate the foolishness of human exceptionalism then we know that becoming is always becoming with, in a contact zone where the outcome, where who is in the world, is at stake'.

In computer systems within ACI, there is this same sense of 'becoming with', that the systems we create need to be an organic extension of the animals' consciousness with the animal being an extension of the computer that thus becomes an animal centric system (Haraway, 1985). The aim is to create symmetric interactions where the parties involved derive a shared meaning. This shared meaning is changed when new technology is introduced (Weilenmann & Juhlin, 2011). This equal transfer of meaning was studied in Washoe, where through the shared system of sign language rather than asymmetric vocalisation, symmetric interaction across species was allowed, fostering cognition research through the emotive conversations held (Fouts & McKenna, 2011). Consequently, in ACI there needs to be an establishment of the custom and task field within the developed technology situation to centre the design to explore the animal users use of computer systems. As the ACI field develops, this is being explored in trained screen situations (Zeagler et al., 2016) but is yet to be investigated within a user centric stance of allowing the animal to explore the technology organically.

2.6.4 Intra-action entanglement in ACI

In home use especially, animal users are not the sole users of systems. There are two ways of exploring ACI systems; as separate entities (as in interaction) or as ontological inseparable agencies (as in intra-action) (Barad, 2007). Intra-action, as coined by Barad (2007), explores the entanglement of matter and meaning in terms of the relation between discourse and materiality: its ideation of engagement. This theory presumes that politics and ethical issues are always part of scientific work. It acknowledges that it is impossible to have full control over everything with the humans' cultural constructs and anthropomorphic beliefs shaping the knowledge that is derived. It is through this acknowledgement of involvement that the science can become more credible, aligning with the theory around post-humanism that object and subject cannot be separated (Schatzki, 2001).

In ACI, Westerlaken (in Hirskyj-Douglas & Westerlaken, 2015) argued that assigning a descriptive meaning to an event for reflection is a human affair whilst suggesting instead that the engagement might be less derived by animals through labels shaped across species. Similarly, in ACI, it appears easier to define what is not than what is within inter-action. In the ACI workshop at BHCI (2015) it was found to be easier to state what is bad rather than good in ACI. It is within this stance that Hirskyj-Douglas & Westerlaken (2015) suggested that it is the spaces between the elements themselves that also require focus within to acknowledge the agencies that play roles. There is therefore a space in ACI to not only examine the animal user's intentions, but also to take an overall scope of the entities, such as systems, people and places in reflection of the findings to bring a more grounded viewpoint and analysis towards methods to capture a dog's attention.

2.7 Previous Work: Dogs' Choices of Visual Media

Prior to this thesis being undertaken, an investigation was done into developing methods to capture a dog's interaction with screen technology. With the growing use of technology globally and ubiquitously, a space has been created for the development of computer systems for dogs in ACI (DCI), where a need arises to research dogs' motivation to their interaction with technology. Whilst ACI systems are often required for impassive dog interaction, such as alarm systems (Robinson et al., 2014), there is also a growing social movement for luxury pet products. This niche makes way for DCI technology to be solely developed around dog requirements (centring) rather than the previously human or joint dog-human entity point of view.

It is worth noting that human users of technology used to have to be trained in technology use, but over time, as human requirements have been brought to the fore, technologies for humans focus on inclusion rather than learning. This thesis aims to take the same premise in dogs as that in humans, where the technology usability aligns with the user's affordances. However, these affordances with dogs and media are not yet known, and as such, this work began with investigating dogs' affordances within the media technology to start the building of guidelines for more usable interactive media technology within DCI.

Before this investigation, applications had been developed for dogs that allowed interaction; the models for these are often based upon HCI instances (Resner, 2001). This became a starting point of this study in DCI to take account of previous HCI methods. HCI methods hold findings in the design and exploration of human usable interfaces, with sub-areas that allow for non-verbal affordances such as child-computer interaction (CCI) (Read et al., 2008). In much the same way as the CCI community has adopted and tested HCI methodologies for specific child users, in ACI, HCI methods can be explored and used. The findings and methods can be looped back into dogs and human counterparts iteratively to strengthen both fields. This investigation also adds to the transferability of methods interchanged, helping to strengthen the numerous links between the two (Chapter 2; Table 7).

This research began by using the HCI methodology of grounded theory methodology (GTM) in DCI to explore if a dog has a bias over the subject choice within media. Simply put, does the media shown to dogs on a screen affect their viewing habits? This study has the backdrop of investigating the transferability between ACI and HCI theories to give insight into a dog's cognitive models whilst trying to align with current research in dog vision with screens (Williams et al., 2011; Somppi et al., 2012; Tornqvist et al., 2015). This previous research had shown that dogs vary their attention towards computer screens, visually viewing dogs the most, then humans and lastly objects and letters (Somppi et al., 2012) (Figure 13).

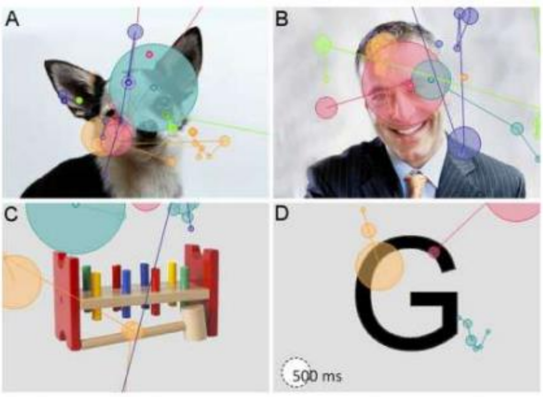


Figure 13. Example of images used within Somppi et al.'s (2012) study using images of (a) dogs' faces, (b) a human's face, (c) children's toy and (d) alphabetic character showing the visual attention using gaze tracking with dogs. The lines represent the gaze across, with the circles representing holding a gaze. The size of these circles is proportional to the gaze length.

Recently, Tornqvist et al. (2015) also found that dogs have more visual scanning, that is, gazing behaviour, when viewing more social stimuli than non-social media stimuli. Tornqivst et al. (2015) noted that this behaviour was like that seen in humans.

A GTM study in an ACI framework was implemented by filming dogs watching media on a TV device. Their interactions were measured using the time and number of interactions along with the dog's owner's assessments. This investigation formed the foundation of this thesis through the outcomes that were derived. This included the preliminary method for quantifying and recording media interactions with dogs and for aligning vision research from pictorial depictions into media instances.

2.7.1 Previous Findings

The previous work presented two dogs with various two-minute-long media clips of different content (animals, dogs and humans) within their own home and recording the dogs' watching behaviour of these videos. The findings of this previous work presented a method at quantifying a dog's interaction with screens over varying media clips by both filming the interaction and using the dog owner's assessments. Initial findings were also derived around how to conduct screen studies in DCI. The work reported in this chapter was published at *ACM-W* (Hirskyj-Douglas & Read, 2013) and published as a master's thesis (Hirskyj-Douglas, 2013).

The method employed firstly looked at the dog's physiology and psychology, focusing on audio and visual communication modes. Once the context and task field were established, the decision was made to use the owner-dog relationship to measure the dog's variables via a human proxy as well as a video footage for quantitative data. Cameras were used, one facing the dog and one above the screen to give an overall viewpoint of the dog's interaction (Figure 14).

Figure 14. Screenshot from videos taken during the study of camera behind the dog (left photo) and camera facing the dog above the screen (right photo)

To align with previous ethical protocols (Mancini, 2011) and to ensure the correct welfare of the dog, the dog could leave the study setup and go to a safe place (its bed).

This resulted in an analysis of the dog's visual preferences from the researcher, from the owner during the study and afterwards from the video analysis. The results were then examined from both the dog and human perspectives to assess methods of reducing the human-driven incentive behind carrying out research with animals. This led to the implementation of a GTM corpus which allowed for the results to sculpt the video categorisation. An initial subject of one dog was chosen to test a multiplicity of two-minute-long videos with the interaction(s), number(s) and time being calculated to create an interactive range to measure the video(s) against. The interaction time of the dog was noted with any behavioural changes noted to build up a framework of dog interactive principles. The GTM framework built was made from noted behaviours of the dogs whilst watching screens: ear pricking, head tilting, approaching the screen and types of watching behaviour.

Whilst the results did not prove that the videos were beneficial to the dog, the two owners' assessments on their dogs' behaviours did report inquisitiveness in the videos. Long interactions were often paired with the dogs approaching the screen and labelled as a GTM concept. The corpus began with two trials: one of a dog-content video and one of a human-content video. As previous research indicated, the dog had higher viewing times with the dog-content video than the human one. This led to the theory that it is the subject within the video which influences the dog's interaction times. To analyse this theory, videos varying from human-human (exp. 1), dog-dog (exp. 2), dog-human (exp. 3), animal-animal (exp. 4) and human-animal (exp. 5) were shown, and interactivity was compiled from the results. These same videos were then tested on a second dog subject (exp. 1 and exp. 2) to compare the results against the initial dog's findings. With the second dog, it was found that initially the dog did not watch the screen. The researcher then lowered the screen to the dog's head height which resulted in the dog watching the screen and forming guidelines of dog-screen interaction.

Initial conclusions indicate that dogs have a bias towards the interactivity of screen devices based upon the media clip shown, aligning with previous research (Williams et al., 2011; Somppi et al., 2012). These results showed that the dog had a higher viewing time with dog-based media clips, followed by animal-based media clips and lastly by human-based video clips.

The results show dogs prefer animals over human-based stimulation despite their human proxy evolution and habitation. This presented a foundation for the context of dog stimulation videos, identifying a future point of research. This study also indicated the importance of the owners' assessments to give further context to the interaction, providing another point of view away from the researcher's own video analysis.

These studies allowed for a dog, at some level, to be involved within the design process regardless of language and created a GTM theory. The dog has fewer interactions but for longer periods with the dog-oriented video than the human-based one.

This method has been transferred from HCI to ACI, and perhaps the biggest contribution that this previous work offered was a way of recording dog behaviour with screens videoing the interactions and then coding this behaviour using the HCI GTM theory. By adapting the study setup, such as allowing a safe place and the screen height, this study provided initial guidelines for dog-screen interactive research. This provides ACI with a method of quantifying interaction away from training responses or attaching technology to the dog as is often done within DCI. This begins a new way of investigating dogs' entanglements within technology, that is, dog-centred design.

Importantly, these previous findings also laid out the initial guidelines and method implementations that are built upon throughout this thesis. These findings helped to form the foundation of ethics and protocols which are developed through the following chapter studies. These findings were as follows:

- The owner of the dog must be present during the investigation to interpret the dog's behaviour.
- A safe place, such as a bed, must be present.
- Any media shown to the dog must not contain images/audio of recognisable items to avoid distress.
- During the setup of the experiment, the dog must leave the room.

- Any human participant must not watch the stimulus or encourage the dog to watch the screen.
- The screen must be the dog's head height.
- Key physiological signs demonstrate dog interest in visual stimuli (labels in GTM concepts):
    - Ear pricking
    - Head tilting
    - Approaching the screen

Whilst the hypothesis developed helps aid the building ACI, it also promotes animals within the HCI environment. The ability to adapt technology for an animal's preference leads back into HCI for specialised technology, where the requirements are analogous, such as those used in non-verbal instances in children. This is where the beginning stages of the importance of conjoining the islands of knowledge between HCI and ACI began.

The resulting framework for GTM HCI to ACI is tested theoretically and in real-world situations with the proposition reached that in dog's dog-based videos have a positive correlation towards the amount of time spent viewing the stimulus. This relationship needs to be scrutinised through further iterations but lays out a foundation for developing a model to analyse dogs within computer systems, beginning the research within this thesis.

Overall, this resulted in the building of a method to test the viewing habits of dogs with varying videos, using recording devices to ascertain a dog's attention in an HCI manner. The findings identified in this study demonstrate a dog's preference towards certain media and the importance of the owner's involvement in DCI studies. Guidelines were derived for future practice, and the HCI and ACI methods of transference were used to provide the initial underpinning concepts and findings with which this thesis is built on through the various chapters.

2.8 Conclusion of Literature Review

This chapter provides an outline of the ACI field concerning technologies, ethics, methods and theories, models and concepts. This literature review has demonstrated that there are currently few, but a growing number of, technologies, ethical considerations and methods in ACI often stemming from and adapted from HCI and ethology. In addition, this literature has identified technologies and methods used in ACI to support gathering the users' experience of computerised systems.

The literature review has shown that there has been little research into the use of screen technologies for dogs (Zeagler et al., 2016; Mealin et al., 2015; Williams et al., 2011; Somppi et al., 2012), this is surprising given that dogs in homes have been using (or at least attending to) screen technology for several years. The technology that currently exists relies upon training (Zeagler et al., 2016), or on expert users (Williams et al., 2011; Somppi et al., 2012) and is mostly studied in a laboratory setting in contradiction of the user centric stance within ACI and the ordinary habitation of dogs within homes. This highlights a gap within ACI for user centric methods and philosophies to be implemented within these situations to empower both the dogs using the technology following the ACI Manifesto guidelines (Mancini., 2011), and the human interpretation through observation of this use (Baskin & Zamansky, 2015).

Methods used have mainly used tracking technologies to study dogs' attention. Dogs have been tracked viewing images by being trained to wear a headset (Williams et al., 2011) or by being trained to hold their heads in certain positions (Somppi et al., 2012). Their general body position has also been tracked using image recognition (Mealin et al., 2015) and they have been shown to be able to use touch screens if trained correctly (Zeagler et al., 2016). The literature did not reveal methods to track dogs attending to screens in natural ways without training or the use of wearables except in the whole body positioning conducted by Mealin et al. (2015).

Part of this tracking paradigm is not only the method to capture but also the codifying of the screen attention. Previous methods have transcribed these behaviours by positions, such as Mealin et al. (2015) who describe the animal sitting, standing and lying. Position of interaction has been described with high fidelity solutions through eye tracking (Williams et al., 2011; Sompii et al., 2012) or direct touch behaviour (Zeagler et al., 2016). Interpretations by human users of the actions seen in tracking have been seen used as owner judgement in tablets (Baskin & Zamansky, 2015; Westerlaken & Gualeni, 2014) and tangibles (Robinson et al., 2014) but no work specifically considers how owners might describe screen watching behaviours.

The overarching theme within both the screen attention and the tracking methods and tools is that choices of methods and designs are made against an ethical position of what the role of the dog is in research studies. Ethics has been explored in ACI through the initial Manifesto guidelines (Mancini, 2011) and then later in Mancini's (2011) work focusing on animal centricity and also through cost- harm scenarios taking an animal behaviour approach (Grillaert & Camenzin, 2016; Väätäjä & Personene, 2013). There however is no ethics work specific to dog- screen interaction and little about working with dogs at home.

As can be seen towards the end of this literature review the research methods and philosophy that is taken in respect towards the placement of the dog within both society and the research space has implications towards how the dog is treated within the research. This requires considerable thought and to that end the next chapter will specifically consider this positioning leading the reader towards an understanding on=f the philosophical stance taken by the author in this thesis of dog-centric research.

Chapter 3

Research Methods and Research Philosophy

"Hounds used to find things using their sense of smell, but now I use a search tool called Google Nose!"

3.1 Introduction

This chapter explores research methods and philosophies within the context of dog-centric DCI. This conversation begins by discussing the placement and relationship of dogs within the human-animal association in respect towards technology. This focused situation of the dog within the research, is then reflected within a HCI light drawing parallels to similar transformations in HCI that associated fields, such as CCI, grew roots from. The empowerment of the dog within HCI research, that is, dog-centeredness, was first mentioned in Mancini's (2011) ACI Manifesto encouraging inclusion. This chapter lays out the research philosophy of dog-centric systems building on Mancini's (2011) animal-centred philosophy. As mentioned in Chapter 1, there are two primary users of ACI systems: the human and the dog. A dog-centric approach aims to put the dog, rather than the human, as the core user of the system. The philosophy of this research is to be dog-centred and empirical.

Section 1 of this chapter looks at the philosophies behind animal-centred design as understood within this thesis and as discussed in the larger body of work. Such philosophies are discussed, along with a categorisation of ACI technology and its relevance in regard to where the dog is positioned in research and design enquiry in ACI. To explore this positioning a discussion is held around the animal-human relationship exploring the ontological and epistemological issues surrounding ACI, questioning how might the ethics and politics be committed to the growth of the dog-computer relationship and considering what can be learned from observing this relationship.

Section 2 of this chapter then reflects upon this philosophy through three approaches taken within this body of work; to the design of, the ability to participate in, and approaches for the inclusion of dogs in, user-centered research. The concept of centring on the dog emerged in the ACI SIG paper (Mancini, 2011), which aimed at using HCI to empower animals. Historically, DCI focused on technology for corrective behaviour in which the animal was expected to fit the human model of appropriate behaviour. In this way, the user at the centre of the design would often be the human. Having a human at the centre of DCI has the potential to exploit animals using technology for human benefit. Approaches within ACI can potentially be described as exploitive if they are corrective computer interfaces for the human benefit only, ignoring the dogs' requirements. An example can be seen in technology that allows the owner to remotely interact with dogs (Neustaedter & Golbeck, 2013), which, while comforting the owner, possibly creates disembodiment issues in the dogs, leading to anxiety and confusion, as noted by Ohta et al. (2016). This typical use of animal technology with roots in 'animals as human tools' has begun to change in recent years with, as current ACI technology grows, the question being asked: *who is the user, the dog or the human?*

Section 3 lays out the philosophy of the methodological stance taken within this empirical research through an interpretivist approach. The concluding section 4 then introduces the two main participants of this empirical research, Dog 1 and Dog 2, laying out the approach taken within the thesis reflecting upon the above discussion.

3.2 Section One: What is a Dog?

In asking the question 'what is a dog?' ethical, cultural and political positions need to be considered along with discussion and philosophy from the intertwining fields of sociology, nature culture, ethology and even, recently, technological science. There are lots of different ways of looking at dogs and pertinent to this thesis is how they co-exist within families as part of a domestic mesh. This section positions the dog in this space by drawing closely to Haraway's (2008) and Sanders and Arluke (1993) ideas on investigating the animal-human relationship and perspective, confronting the research issues of exploitation of anthropomorphism and the psychological interpretation of an individual's actions within a story.

Understanding the dog and its relationship with the human suggests that neither the romanticisms of the notion of benefiting dogs through human desires Ackerley (1956), nor the economic growth around inputting human morals (activity trackers, dog video callers and treat givers) to dogs is entirely useful to ACI. The work of this thesis takes the relationship between a human, dog and technology seriously by placing the dog not as a cog within a mechanical system but as an active participant in a system that is 'organic and technological', (Haraway 2008, p4). This stance agrees with Russell (2011 p144) on the ways to consider how an organic being, when acting for the human in doing human work, can itself be described as a symbiotic technology.

Haraway (2008) wrote about her grandchild learning to train her dog, describing the dog and technology as being elements in the same 'game' that become to be, with the child, 'significant others' to each other each paying attention to what is being said. Understanding what is being 'said' by the dog to the technology and understanding the relationship between the dog and a human actor is core to being aware that this is a system rather than to consider each part separately. Thomson (2005) coined the phrase, "ontological choreographies" to describe the beauty of such skilled dialogues.

The dog-human tie, especially with pet dogs, is considered in this thesis where the tools laid out seek to capture insights into the perspectives of the dog owners, personas (Chapter 4) for aiding in understanding a dogs' requirements initially and informed observers (Chapter 5) to facilitate during owner annotations. These tools nevertheless seek to understand the animal's perspectives themselves, following Sanders and Arluke (1993) reasoning that emotional experiences serve as a valuable source of understanding.

This thesis comes into the world of ACI from an animal's perspective by allowing the dogs to behave how they feel and by using interpretation of behaviour in natural places (the home) to derive results. The risk to this approach is that it can lead to, what Sanders and Arluke (1993) term "inappropriate" non-judgemental ethnography as the observer is, in every way inherently and biologically. not a dog. A second conflict is shown in terms of the extent to which behaviour of a dog can be interpreted by a human.

Goode (2007) questioned if it was appropriate to describe animal behaviour in such a way as to assume that intentions pronounced are intentional – suggesting that as humans we map our mental states onto animals. This approach, however, is widely used and is supported by perceptions, and data (Sanders & Arluke, 1993). That is not to presume though, that such perceptions, and indeed human gathered data, is not traditionally anthropomorphic by virtue of the relationships of the dog to owner. The stance taken within this work is that at a minimum echoing Sanders and Arluke (1993) thoughts that if an animal can think in rudimental ways then so can it feel in abecedarian ways. It is however quite possibly that animals may well feel emotions beyond our own spectrum (Masson, 2004).

Theory of Mind (ToM), as an explanation of choice making, was instigated with an investigation into chimpanzees (Premack & Woodruff, 1978), and is steeped within the differing arguments of learned behaviour such as associated learning (Elgier et al., 2012). Evidence for it with dogs is demonstrated in work showing dogs outperforming non-human primates in ToM tests (Maginnity & Grace, 2014). Sanders and Arluke (1993) believe that ToM can be seen as presumption and projection – which could be the case within the analysis drawn within the tool sections of this thesis; evidence is growing for a rudimentary theory of mind in dogs (Horowitz, 2011; Roberts & Macpherson, 2011) and towards a belief that animals can make judgements and use persuasion comparable to human-to-human interactions (Sanders & Arluke, 1993). This intersubjectivity has also been investigated within the groundings of animal-technology (Gergely et al., 2016) and is the premise of investigation here. However, whilst it is proposed that dogs and humans may recognise each other's mental states it is not known if either of these can directly know and experience these (Goode, 2007).

Sanders and Arluke (1993) refer to an intimate interaction between dog and human where each gets to 'know' the other. This 'knowing' is used within this work with the dogs chosen being familiar to the researcher. On the one hand, this can present ethical and emotional challenges but it does allow sensitive ethnographic work as Mies (1983) coins ‘conscious’ partiality grounded in animal-centered methods that allow the deconstruction of domination.

Human judgement of their animals’, in this case dogs’, emotions, although open to anthropomorphism, can productively be applied to the study of human-animal relationships (Herzog and Burghardt, 1988). It is through these two-way conversations between dog and owner, as Haraway (2008) suggests, that a new definition of intention could be employed within ACI to study, what Hearne (1987) terms ‘two-way intentions’. Two way intentions could be described as conversations between dogs and animals, between dogs and technology and between dogs and humans. Sanders and Arluke (1993) take this conversation convention building from Hebb (1946) believing these two-way intentions to shape the behaviour of the other (dog and human) to communicate understanding and goal giving. It is thought that the dog, even if as mentioned at a rudimentary sense, can ‘take the role of the other’. This symbolic redefinition of objects, as Resner (1990) noted with tug-toys and Sanders and Arluke (1993) with sticks, created a combined definition of basic rules for such interactions (Sanders & Arluke, 1993) varying according to the participants and the situation.

It is upon this foundation that, even if at a basic level, animal’s emphatic, as suggested by Sanders and Arluke (1993) perspective of their others is an occurrence and following Goode (2007) that dogs have control over their intentions. As Wieder (1980) talks about ‘mutual orientation’ at the heart of animal-human interactors in traditional human terminology, conversely Westerlaken (2015) believes this whole notion to be a human agenda. This research takes Sanders and Arluke (1993) viewpoint of ‘taking the role of the other’ in Haraways (2008) stance of ‘becoming with’ to communicate in the appropriate style using technology, as animals have employed with themselves and us. As Sanders and Arluke (1993) noted, the most useful information can come from these direct observations. In this way, this thesis builds upon the foundation of animal community that stress a central methodological and practical importance of appropriate behaviour and expectations of the animal interacting. It is this beginning step that the studies prelude to through iterations to learn to interact appropriately.

3.3 Section Two: Philosophies Behind Animal-Computer Interaction (ACI)

There are many methods implemented by researchers within DCI, some taken from HCI and its specialities such as child-computer interaction (CCI) and others from animal behaviour, animal welfare and ecology (scientific interactions of organisms). The discussion below looks at how HCI and animal behaviour have been applied to ACI. This discussion is primarily focused on DCI, with examples of method use taken from other ACI studies.

With ACI presenting a shift from traditional animal behaviour research in the connections and reframing of how research is done with animals, the below discussion looks at current research methods done. From this discourse, a model is presented in which to frame these research methods around. Building on this model of centeredness in DCI, an approach is laid out of how to think about dogs participation within ACI. After this discussion, ethical principles are given which this thesis follows, and these principles are later reflected on in the concluding chapter (Chapter 9).

The approaches reported within 3.3.1 in this section were published at *The First International Conference on Animal Computer Interaction* at *Advanced Computer Entertainment 2014 (ACE'14)* (Hirskyj-Douglas & Read, 2014), 3.3.2 published at *British Human Computer Interaction (BHCI'17)* conference workshop on *Animal Computer Interaction* (Hirskyj-Douglas et al., 2015) and 3.3.3 published at *Measuring Behaviour (MB'17)* conference workshop on *Animal Computer Interaction* (Hirskyj-Douglas and Read, 2016).

3.3.1 Approaches to the Design of Dog-Centric Technology

HCI principles can be, and have been, applied to DCI to investigate the method transferal, as seen in the authors' early work, referenced in the literature review, which used GTM. One HCI method often mentioned in DCI is co-design (Westerlaken, 2016). With roots from UCD and participatory design (PD), co-design focuses on the design with it being well researched in HCI that the more the co-designer is able to talk with the user, the better the shared meaning becomes (Sanders & Stappers, 2013). *Is this the same for ACI?* Looking towards how HCI negotiated this communication paradigm, with disabled children, Frauenbergee (2012) uses communicative aids, such as toys with autistic children, based upon their specific needs. Within human-dog communication, communicative aids have extensively been used and more often learnt through the co-habitat environment and investigated through object importance (van der Zee et al., 2016). Westerlaken (2016) argues that by drawing from Bruno Latour's and Donna Haraway's philosophies on situated approach with animals, this reflection process results in an understanding between the human and the dog as is discussed above, resulting in participatory research. *Is this evidence of co-design in ACI though?* This philosophy relies upon the dogs' understanding that they can co-shape their environment, that is, that the environment is 'interpreted' and 'appropriated' by the dog users (Westerlaken, 2016).

Mancini (2013) advocates for participatory design research in DCI stating that as an animal uses the system, the animal is inherently a participant. This argument presents itself as the systems aligning with the animal users' 'viewpoint' (physiology and natural behaviour) to enable reliable evaluations from the animals' perspective. Whilst this body of work acknowledges the importance of the relationship between owner and their dog, the shared knowledge that is situated between the two users of systems (owner and dog) is mitigated by the dog's owner not in a co-design process but instead within human interpretation where the dog's thoughts upon a system (if indeed they think in this way) are never fully stated. It is within this light that the dog choosing an option within a system, as seen within this thesis, is not considered participatory design as the dog is a user of a system. This action is seen as an outcome of the method put in place.

> *'we cannot know what is natural behavior for chickens if we examine only chickens who were hatched in an incubator…This is a warning to those who conduct experiments without taking into account what happens in a natural setting'* – Masson (2004, p65)

As shown through this example, this highlights the main challenge faced when forming methods to capture a dog's behaviour: interpretation. In ACI, it is impossible to exclude the human from the study, particularly as a researcher it is impossible to fully step away from the procedure (Barad, 2003). Within this thesis, this stance, that is, mitigating the translation paradigm, is aimed towards not interpreting the behaviour but instead taking the behaviour for what it is and that which can be observed. This is the process used within this thesis, where dogs are simply given a device to use with the requirements being drawn from the dogs themselves. This stance has led to methods being formed in DCI, but if this is truly dog-centred design, however, then *where is the centre of the design?*

This user-centric philosophy has been discussed in DCI within the context of trained and untrained behaviour. Often in DCI, methods and products are implemented that require the dog to be trained to use a system (Zeagler et al., 2016). This shaping of behaviour in DCI has been shown to be a useful input for systems, such as in Mancini et al.'s (2015) work, where they monitored the length of a dog's sniff on cancerous and non-cancerous samples to draw at a dog's signalling. This action of actively training the dog to use systems is not used within the thesis research to avoid shaping the dogs behaviour and thus affects any results that are gathered. This is not to say that self-taught training in DCI systems does not occur though through the dogs' learning how to use a system themselves but this thesis does not use trained methods to draw at a dog's ordinary, that is, untrained by the human, behaviour.

Traditionally dogs have become ritually humanised through breeding to meet human needs and through our choices of keeping them as domesticated pets. They take part in human transport, work and play, taking on multiple roles within human society. Whilst the idea still exists to create technology for dogs that do not need any training, for the dog to understand the initiative of the designed technology, a certain amount of explorative work has to be taken with the dog, that is, a level of exploration. This argument brings to the forefront the realisation that no dog in ACI is fully without training, even by exploration, *but is there a difference between explorative training and training for a humanised goal? Where is this line drawn?*

The root of this question, this author believes, is whether the end goal of the technology is human or dog centred: who is the technology designed with and for. We question that if the goal is human, then would the dog naturally explore the technology in a humanised way through the dog's then trained behaviour, and as such, is this use not human centric as the goal and task is not for the dog's benefit? In DCI, a majority of the research done is through, or on, trained behaviours, the usability of these systems and training methods. Whilst their interpretations of these trained results are useful to DCI, and ACI indicatively, these results are not based upon the dogs' true intentional needs, usability and requirements but instead based upon their requirements within the training humanised situation.

Simply put, if a researcher designs a system for a dog, trains the dog to use this system then evaluates this process, they are only evaluating a dog's usability of a human-made system, drawing requirements from the human process itself. This juxtaposition, whilst theoretical in nature (human vs. dog centric), has outcomes towards the given findings and thus the recommendations and future of the ACI field. This is noted within this thesis, where unlike previous work within screen watching (Somppi et al., 2012), which found that dogs like to watch other dogs, our work has often found a dog likes to watch nothing (tool 2 [Chapter 5] and study 3 [Chapter 8]). This result is impossible with trained watched behaviour where the dog was almost unable to look away from the screen.

Through this discussion, it has become apparent that, like HCI, there is no perfect solution to designing technology for dogs, but without the exportation of their needs, this solution remains even more elusive. The authors believe that unless DCI is explored in a dog-centric manner, the needs and requirements drawn from human-centric studies could be an imprint of the human desires and thoughts upon the dog's needs particularly where training is involved. Whilst throughout this thesis it is acknowledged that unlike the traditional viewpoint of science, the human is inherently tangled within the interaction, the depth of this entanglement influences the conclusions drawn from such studies.

In DCI, technology can be made that allows a dog to explore computers, like humans do, to find requirements by exclusively focusing on a dog's ordinary behaviour. Humans will always be involved as the computers' creators, but by making the dog the centre of the design gradually by building up requirements, this centre of built-up knowledge can be transferred across to make more animal-centric systems. Whilst it is unconceivable that a dog will be able to write a list of software requirements, they can input through their communication medium of behaviour accepting that, but this does not draw at their intentions but only their actions.

The position taken through this thesis is to design exclusively for the dog to create this version of DCI whilst trying to exclude, where possible, the human-centric aspect. This method is coined dog-centric DCI. This is within the acknowledgement though that we as humans can never know the centre of DCI as we can never fully understand a dog, but strive to aim towards this nonetheless within the paradigm of what a dog is as stated above.

There is a clear parallel between early HCI software development and current DCI research where there was a realisation of the importance of the user being involved within the system. It is only by letting dogs explore technology through their own eyes, that is, ordinary behaviour, and not the human gaze, that these needs can be shifted into dog-centric methods. For the centre of the design to be the dog, then the dog should be inherently motivated to use the technology itself in an ordinary manner through exploration.

3.3.2 Approaches for the Modelling of Participation in Dog Computer Interaction

The practice of centering technology for DCI draws up questions of the ability of a dog's participation within the system dialog. Throughout this chapter, opportunities for dogs to participate in developing methods of research for DCI have been discussed with the participation of dogs within DCI technology being seen in different degrees through various projects and research initiatives. Whilst it can be argued that a dog participates within a study to the extent it influences the results derived we argue that through confidence and competence, a dog's participation can be gradually increased and improved through practice and by finding methods that allow dogs to be involved transcending the spoken language barrier. Mirroring Harts (1992) ladder of participation in an endeavour to sculpt this equilibrium, of humans and dogs, a doggy ladder of participation (DOLP) (Figure 15) is presented to encourage DCI designers think further about ways to include dogs within their research. The DOLP model is split into two halves: nonparticipation and participation.

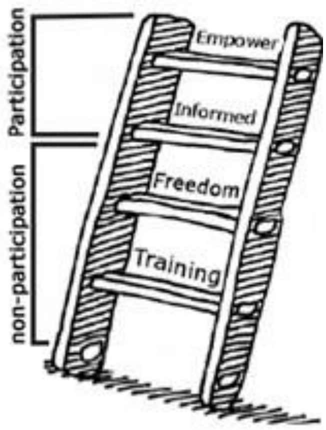


Figure 15: Topology of the doggy ladder of participation (DLOP) showing the four rungs: (1) training, (2) freedom, (3) informed and (4) empower with degrees of participation and nonparticipation.

This DLOP is not seen as a progressive hierarchy in which the participation roles that dogs take in DCI should be developed but rather a method to look at how inclusive a dog's participation is within technology to encourage further inclusion. Whilst this ladder only has four rungs, this does not mean that as DCI technology and ways of measuring and inferring behaviour advance, methods of dogs' participation within DCI will not transcend beyond these current rungs. In this way, there is no limit of the involvement as suggested by Treseder (1997) when speaking about children. This is taken in the animal sentience stance of excluding what a dog cannot do rather than proving what a dog can do.

The first two rungs training and freedom are described as nonparticipation as the dog user is included within the process but is not actively participating with its ordinary views contributing in a meaningful way towards the technology. Training is the lowest rung of nonparticipation and represents an example of an ornamental form of participation. The dog is manipulated within the ACI study without any understanding, often 'forced' via a reward or treat. The use of a treat/toy is often used as a progressive form of training where a token is given to dogs to thank them for their input. In this way, training within ACI, whilst it can give useful results, does not allow a dog total freedom of expression or to use the technology within an ordinary way. From this category, a dog's factual acknowledgment can be drawn (such as drug detection) but not their belief and opinion. The key flaw to participation through training is that little or no feedback is given by the dog, and the dog does not give consent to participate. Whilst a dog could never sign its consent in a humanized manner, the dog does have the ability, but not always the right, to 'walk away'. This belief of consent has been strongly advocated in the ACI community (Mancini, 2016) and within this thesis. This ability is key within ACI study proposals, as if the dog is forced to give feedback, it could be both a biased result and meaningless judgement for a dog within the process.

Freedom participation is the second nonparticipating rung on the DOLP. For this, the study is still an owner-led activity, but the dog is free to do what he/she wants without training or manipulation through treats, toys or other incentives. The ability for a dog to walk away allows a form of given consent. This rung gives a minimal voice to dogs, but they still have little/no choice about the style of communication. However, the two key differences between training and freedom participation is the ability to walk away without the bias of an incentive or a forced feedback. Through this ability to walk away (attention/nonattention), the body language, biological feedback and vocal signals can be judged as a simpler preference. These choices nevertheless still have little impact upon the design other than a yes/no form of consensus. Moreover, the initial decision and method process is still made by the human designer, with the animal having no input other than acceptance/denial.

Empowerment and informed are forms of active participation, as they allow the dog within the DCI technology to engage an active role within the processes influencing directly the technology systems and having meaningful interactions. Within these rungs, an acknowledgment is given of equal standing for the dog by allowing them to change the technology system directly whilst being invited to contribute their views and opinions. This shared process of responsibility is partly conceptual but is forward-thinking towards advancements in both animal technology and animal behavioural science.

In informed (third rung), the dog is consulted through its body language on its choices, which have a direct impact upon the design. The analysis of the body language is more complex than a yes/no consensus, with questions into how the dog's emotions and cognition influence its choices. Such analysis seeks to understand why the dog makes each choice (the dog's experience and intentions). This brings a more in-depth viewpoint to the pronouncement rather than just accommodating the result. Within this rung, the dog is also empowered by understanding, in part, the intentions of the project. Whilst it is currently unknown if a dog fully grasps the whole concept, through repetition it is thought that a dog could understand that their decisions have an impact upon the design concept as a whole through their understanding of social situations (Hare & Tomasello, 2005). Similarly to young children, it is possible for a dog to understand that their actions cause a reaction without always understanding the cause (Hare & Tomasello, 2005). This use of dogs within ACI is aimed at progressing their use beyond tokenism. To use this rung, the designer must make sure that the dog is included within the design to have a level of understanding and is not simply included within the design to qualify as participation.

The fourth rung, 'empowered', is a conceptualised ideology, where it is hoped, through the advances of animal biometrics, animal behaviour and computer technology, it would be possible to gain more insight into a dog's thought processes and thus its opinions. Here, a dog would understand that its choices would have an impact upon the design and would therefore understand, in some part, the outcomes of its choices. The dog's choices will also have an impact upon the designers/activity and thus decisions/activity; in this manner, the designer and the dog are of equal partnership. Dogs and humans often have unspoken conversations, where both sides understand the emotions and outcomes of this discussion (Haraway, 2008). It is thought that through these conversation, the duo, through meta signals, perform together better whilst knowing their own flaws (Bateson, 1951). It is with this acknowledgement of a constantly occurring conversation often through body language (Haraway, 2008; Dodman, 2014), that this can profit both the dog and the human for improved technology. Capturing this conversation, through including technology within the meta signals to fit the conversation conventions, could greatly enrich both ACI technology and the dog's own understanding of the decisions/activities. It is within this rung that the ideology sits of a fully inclusive equality of participation.

Throughout this conversation around the different rungs in DLOP, it has been noted that there is a recurring theme of two main principles: the knowledge that the dog has of the activity and the right not to participate within the activity (consent). This has been modelled in Figure 16.

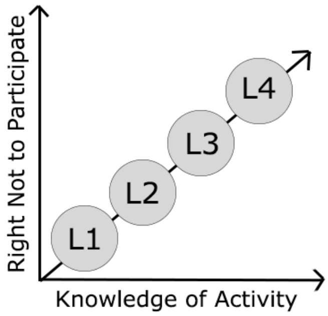


Figure 16. Axes showing the DLOP levels increasing in the knowledge of the activity and the right not to participate as the levels rise. L1 – Training, L2 – Freedom, L3 – Informed, L4 – Empowered.

For an animal to have knowledge of the activity taking place, the activity has to have meaning for the dog. This model therefore brings to light the question, what is meaningful for dogs? Whilst in vocal communication this question has been well-versed (Dodman, 2014) on what a dog can and cannot understand and while it has been approached in socialisation (Hare & Tomasello, 2005), this is on a simpler level of what a dog understands, not what is meaningful. For instance, a dog can understand that he/she is being asked to wait and then given a treat, but meaningful interaction is applied when the dog understands that when they wait before crossing a road and given a treat, the whole interaction holds meaning; they are waiting before crossing a road. Meaningful ACI is therefore about the animal having a sense of performing a task and a reasoning behind the activity: the knowledge of the activity.

Stemming from this, there is a debate around what level of participation is the most meaningful for dogs, shared in Hart's ladder criticism (Fletcher, 2008). This can either be seen as meaningful decisions with the most benefits towards both the animal and the human involved or that dogs are most empowered when they make a decision uninfluenced by the humans. Studies have been conducted to show that dogs will often gaze towards humans for help in decision-making (Miklósi et al., 2003; Teglas et al., 2012) particularly in impossible tasks, implying that dogs rely on the human role of support, similarly to young children, within misunderstood situations (Soproni et al., 2001). Still, equally the human gestures can influence a dog's decision (Soproni et al., 2001). Ultimately, both arguments have merit, and it is up to each researcher to determine what can be seen as meaningful to the dog within the individual situation and to what level the human's participation vs. that of a dog within the roles of decisions which are held within the study.

A criticism of this model can be that the top rung does not put the dog fully in charge but instead advocates for equality within participation of both the human and animal users. Systems developed for dogs have an inherent impact on their human counterparts. This acknowledgment leads to an implied equality, where all those within the system should have a voice and be involved actively. This makes equality more morally superior to one type of participant being 'in charge' (Hart, 2008). Another criticism of this model is the danger of adaptation from a developmental tool into a comprehensive evaluator. As ACI, and the subfield of DCI, is a new area of study, there is still so much to develop in the realm of evaluative tools. Whilst DLOP can be used to enable researchers to monitor the degree of agency of the dog, or be adapted to other animals, there is also scope for modification upon different stages within projects rather than initiation as done with children (Jensen et al., 2000). This could be expanded into evaluations for the degree to which dogs understand the extent of the interaction, right to consent, opportunities open for decisions and the ability to be involved as is the case with children (Gaitan, 1998). In this way, the ladder is important in opening up the beginning dialog of participation with an often-undervalued animal participant.

During this conversation, when working with dogs in ACI, the crucial component for a successful participation is not the apprehension behind the language barrier that prevents involvement in our designs but our methodology of inclusion that does not empower the dog enough to provide invaluable feedback. This is modelled here as the aim towards participation being towards the dogs right to participate and the knowledge the dog has behind its activity. This model seeks to bring adjustment by increasing participation through active discussions around participatory development with animals and researchers equally in ACI. In this way, this section brings no defining method to increase participation but instead opens up a space for discussion which is needed to derive more accurate results allowing animals to shape ACI jointly with their human counterparts and empowering the animal's role within the technology they use. Perhaps in this way, this model is not designed to, post research, rank the methods of data capture within ACI but instead to encourage participation and equality from the human part of the DCI interaction.

3.3.3 Approaches for the Inclusion of Dogs in User-Centred Research

When designing technology for dogs, consideration should be taken of the ethical practice of the study. This consideration of the application is not only to ensure the dogs' welfare, particularly as they cannot explicitly give consent, but also to ensure as precise results as possible. This statement is particularly relevant when gathering dogs' behaviour which could be influenced through trained and human behaviour (Shyne et al., 2012). Notwithstanding, animal rights have set boundaries for ethical protocols such as the Animal Welfare Act (2006) within the UK having one of the highest standards for animal research (Mancini, 2016). DCI researchers will often use methods based on what is available, what is ethical and where the researcher feels situated in their research. In this thesis, the author chooses the following eight principles to guide her work which were based upon the study and tool findings. These principles are presented as being specific towards dogs within a media and screen technology environment. These guidelines are coined *Guidelines for Dogs Attending to Screens and Media.* The work reported in this section was published at *Measuring Behaviour (MB) 2016* (Hirskyj-Douglas & Read, 2016).

1. Enable Consent: Walking Away. The dog used in the study must be able to walk away from the study, allowing a low-level form of consent and freedom.

2. Provide Some Familiarity. The dog must have familiar items in the study space available to them. This can take the form of a dog bed, blanket, toys and other items which the dog is familiar with if working outside of the home. These items help the dog feel a level of comfort to potentially minimalise stress felt by the dog.

3. Work Where Possible Within the Dog's Own Home. This study location allows for dogs to both feel comfortable and display normal behaviours as they are familiar with the setting.

4. Have the Owner or Carer Observing. Ideally the owner will be in the study space with the dog or observing the study. Trained professionals in dog behaviour can spot any potential long- or short-term emotional trauma, but equally, the owner of the dog often knows habitual behaviours and will quickly be able to spot and identify any adverse effects. This also has the benefit of enabling the dog to seek comfort if it feels the need to from the owner.

5. Be Mindful of the Dog's Possible Stress and Confusion When Presenting Media. In DCI, researchers should avoid creating potential confusion and distress to the dog by avoiding showing media (audio and visual) representations of people or non-human animals they know. This includes not presenting the dog with any media which could cause distress. Media used with dogs should be tested in a pilot manner first.

6. Dogs Should Be Screened for Emotional Behavioural Problems. Dogs included within the study should be screened for emotional behavioural issues. This can be done by asking the owner or carer during recruitment about any issues that may be present. The reason for this is twofold: firstly, the chance of a possible negative effect upon the dog is greater due to an instability of behaviour and secondly, there would be some distortion of the results with abnormal behavioural responses.

7. Pilot Research Designs and New Systems. Similar to humans, usability testing of systems is important and can help reduce problems which may cause ethical issues. Systems therefore should be tested out in a controlled environment with a singular dog first before implementation. This assessment of systems can, paired with expert support, mitigate the risk of implementing new methods and systems.

8. Avoid the Use of Systems That Require Training. Dogs should not be trained to use all or part of the systems from the human. This is to explore a dog's ordinary attention to screens.

3.3.3.1 Principle Formation

Giving further insight into these principles, below is a summary of these principle's formations that informed the above guidelines. In the previous work (Section 2.7), which explored capturing a dog's attention to screens over various media, owners were instructed not to watch or give the dogs cues to pay attention to, the media. This was due to it being known that dogs follow human social cues, such as gazes and points (Hare & Tomasello, 1999). Data here was also collected within the dog's own home due to more normal behavior being displayed by the dog vs in a lab where the dog was more prone to show exploratory behavior (guideline 3). Due to this, the dogs involved often walked away from the media, but this only showed disinterest within the stimuli so was not seen as null data. Within this study, the owner was also involved to ensure the welfare of the dog(s), especially when diverse forms of media were used which could possibly have had a negative effect (guideline 4). It was decided early on that dogs should not be shown media that would be distressing, which it was noted happened with media (sound/images) of known animals (guideline 5). This was further avoided by making sure that no dog involved within the study had behavioural problems to ensure that both the results were not skewed and to ensure the animal's own welfare (guideline 6). In study one, where a head tracker was developed, the key ethical issues were twofold: firstly, whether to train the dog to sit still to allow for eye tracking and secondly, failing this, to attach a device to the dog's head. There is tension in eye tracking as the most accurate results are at the pixel level which requires methods (eye to gaze to face to body) which put more restraints on the dog thus affecting normal behavior (guideline 7). Whilst Somppi et al. (2012) chose to train the dog to look at the screen to collect pixel-level tracking, the dog was not allowed to look away from the screen (trained to position head on a headrest) causing data collection even when the dog was not visually interested. Researchers in Lincoln (Williams et al., 2011) took a different approach that allowed the dog to have freedom over movement but strapped a device onto their face. Even though positive reinforcement was used to get the dog used to wearing the apparatus, this training would have had an impact upon the visual patterns of the dog. This highlights the tension between accuracy vs. natural movement. In this thesis, it resulted in the decision for a contact-free approach to allow for normal behavior but having the effect of reducing data collection. In study two, where a method was devised to monitor a dogs' attention between multiple screens, a lab environment was required (due to the technological requirement) and it was at this point that the need for a safe place was highlighted to enable the dog to retreat away from the study (watching media) (guideline 1 & 2). This did result in null data being collected (dog going to bed) but this ensured the dogs welfare. Study three, where a dog could control a system called DoggyVision through approximation, formed guideline 7 where a system was developed iteratively with a dog to ensure its suitability.

These principles, as outlined above, are applied throughout the thesis and are reflected on for their impact on the research in the concluding chapter of the thesis (Section 9.2.3).

3.4 Section Three: Interpreting Research

The approach taken in this thesis, as outlined above, is empirical in nature taken in an interpretivist approach seeking to understand the dogs experience with the goal of understanding the meaning behind this interaction, aiming to see the world through the eyes of the dog undertaking the study (De Villers, 2005). This interpretivist research is facilitated within this instance through participant observations and unstructured interviews with the dog owners aligning with qualitative research. This notion of interpretivist ethnographic research fits in with the concept given above of what is a dog of an individual intricate being and may not understand the same objective reality. This empathetic understanding approach conjoins with this researchers emotionally dog-focused naturalistic, participatory approach laid out in Sanders and Arkluke (1993) work that is emancipatory allowing the reconstructed perspective on the place of both dogs, and the humans involved, in technology and nature. This is seen throughout this thesis where often reliability, for instance dogs walking away from the study and playing, and representativeness with few participants provides greater method validity. The ethical guidelines given also reflect this stance preferring a natural setting within the dogs home. Whilst it is acknowledged that this shared understanding between the dog and human, as Haraway (2008) calls it 'becoming with', may not be understood cross species, the dogs used within these studies have an intimate relationship with the researcher with the constraints and situational constraints recognised. It is through this approach that this research attempts to understand the phenomena behind a dogs' attention to screens and how to quantify this behaviour. This is within the assumption that dogs create and associate their own subjective and intrasubject meaning sharing aspects of reality (Goode, 2007) not refuting biology or the biological difference (Crist & Tauber, 1999) resulting in never being understood directly taking the understandable and intentional motivational approach to animal-human communication.

3.5 Section Four: Dog Participants and Approach Taken in This Thesis

The approach taken in this thesis is to deeply study the behaviours of a small number of dogs in order to illuminate methods and theory. To counter this approach, the work also considers a wide variety of potential dog beneficiaries of the research by suggesting ways to work through owners in the study of dog behaviour and by collating a large data set of dog behaviours and traits that can be of use to other researchers.

Two dogs are the core participants in this work. These dogs, Dog A and Dog B (seen in Figure 39) are both neutered male Kennel Club (KC) black Labradors with no behavioural problems. Dog A is owned by the researcher; Dog B is owned by the researcher's father. Dog A is 136 cm and Dog B 120 cm long from nose to tail, with Dog A being 22 cm at its thickest point and Dog B being 18 cm. Dog A was older than Dog B by two and a half years with the dogs ages at the time of the studies given within the chapters.

This choice, to work with dogs that were familiar to the researcher, was taken in line with the principles outlined in Section 3.2.2 above. To compensate for this small sample, the tools created in chapters 4 and 5 sought to include a very large set of dogs to contribute a landscape against which the research could be viewed.

3.6 Conclusion

This chapter discusses the socio - philosophical position that the dog takes within research and, from this, lays out the approach of dog-centric, participatory and ethically situated interpretivist research that is employed throughout this thesis. This approach is taken with the aim of reducing the role that the human user plays within the process, thereby focusing the technology around the dog user by primarily emphasising the results gathered around the dog. This is within the viewpoint that a dog is an individual being that can make active choices, reflecting upon the dogs' mentality, with the owner having the ability to interpret the dog's behaviour to derive meaning.

These assumptions are investigated further throughout the following three studies and two tools. The subsequent two tools chapters provide a way to talk and think about dogs within a DCI context; with tool 1 reflecting upon what a dog is, investigating questions about a dog's personality, character and traits. The tool considers how to reflect these into initial designs for animal technology systems. Tool 2 then takes these notions further, by seeking to enhance the interpretation behaviour, the relationship between the human and the dog, to bring further understanding to the ACI research space.

Chapter 4

Tool One: Animal Personas: Representing Dog Stakeholders in Interaction Design

4.1 Introduction

This chapter describes tool 1, the development of personas for dogs to support the foundation of animal-centred design through forming user-focused designed technology. This work builds onto the narration of this thesis through creating an application, personas, to help the DCI system's initial implementation to focus around dog requirements rather later in the stages of implementation. This tool switches from focusing on eliciting dog requirements to aiding at gathering the human evaluation of requirements building upon the notion of different dogs' personalities being reflected into the design of the systems they use. This work aims to develop dog-centric products, another theme within this thesis, by bringing a well-used human-computer interaction (HCI) method to ACI. Through this exploration, this chapter contributes a product as well as an explanation of the method used so that its findings can be useful to other areas of ACI. The personas created in this study are specifically for DCI with media systems and therefore add to the current toolset of methods for ACI. The work reported in this chapter was published at *Human Computer Interaction 2017 (HCI'17)* (Hirskyj-Douglas et al., 2017).

The goal in designing systems for users is to both create a positive user experience and have high acceptance (Frawley & Dyson, 2014; Moser et al., 2011). This is underpinned by two success factors of involving the end user and understanding their needs. This is particularly important in any research space where there are special users (Moser et al., 2011), and thus potentially where the users are animals. Although ACI researchers aim to involve the end user in design and fully understand the end users' needs, there can be considerable guesswork. This issue was noted in the ACI@BHCI workshop (2016), where ACI researchers concluded that design can be a game of approximation in which researchers often implement what they believe is best practice relying on data from animal behaviourists and from their own knowledge.

Enhancing system designers' understanding of animals' needs is expected to assist researchers to build more successful systems. It is towards this goal of supporting DCI media systems' implementation that this chapter aims to support. This aim also works towards the overall encompassed goal of creating transferable methods between ACI and HCI to enrich both fields (Where ACI meets HCI, 2016). The sharable goal between these two fields, ACI and HCI, of designing products for users who are beyond the normal borders of design can strengthen both fields through connected thinking and interchangeable methods (Mancini, 2011).

To accomplish these goals, a growing trend in ACI is to design using an animal-centric approach (Chapter 3; Mancini, 2016). This animal-centred approach aims to include the animal within the design process by making the animal an intrinsic part of the system (Mancini, 2016). In ACI, as in HCI, this user involvement can be difficult to achieve as there may be restrictions on access to certain animals, there can be a shortage of participants and there could be some danger to the researcher. When working with animals, there are also ethical considerations to be considered as the animal has limited abilities in expressing itself (Mancini, 2016). Traditional methods such as interviews and questionnaires cannot be used with animals to determine requirements. Owners can be quizzed, but with so much intra-animal variation, either large datasets are needed which require extensive analytical interpretation or, in singular instances, the results can be so individualistic that design is difficult. Overall, the task of acquiring and interpreting end-user responses in ACI can pose a very real difficulty. This is not entirely different from some areas of HCI, such as in the design of technology for babies.

Building and developing personas is known to assist in these situations. Initially developed by Cooper (1999) for HCI, personas are models of users focusing on their goals during an interaction with an artefact (Blomkvist, 2002; Cooper et al., 2014). Literature offers four different perspectives on personas: Alan Cooper's goal-directed perspective; Grudin, Pruitt & Adlin's role-based perspective; and Nielsen's engaging and fiction-based perspectives (Nielsen, 2016). Within these persona methods, as Moser et al. (2011) point out, there are two main research topics: (1) making them more memorable for those who need them and (2) studying how to develop and create personas.

As a concept, personas in ACI are not novel, having been explored in two previous instances for particular design applications: one in dog assistant alarms (Robinson et al., 2014) and one for individual chicken users in food systems (Frawley & Dyson, 2014). With dogs being the most researched animal in ACI, building personas for DCI is adopted from Robinson et al.'s (2014) foundation of creating user-centred design (UCD) dog computer systems. The personas generated in the present study will additionally be concerned with the dog as a user of DCI media technologies.

This chapter adds to Moser et al.'s (2011) second focus on personas of development and creation through an analysis of methods situated in the current DCI focus. This is done by creating questionnaires for dog owners to form a data storehouse and from this crafting six role-based personas for DCI media systems split by breed, age and living status. These personas are validated for their usability by contacting DCI researchers and by putting them against current technology. The overarching goal of this chapter is to develop and validate personas for media DCI systems from collected data for both rescue and pet dogs, adding to both the ACI and HCI fields from real data, strengthening the pathway between the two fields and for future ACI researchers. By testing this transference, it builds better methods for voiceless users to represent end-user requirements, both non-human and human, allowing designers to base their decisions from real data personas by avoiding assumptions, making the designed technology user-centred.

4.1.1 Research Questions and Goals

The goal of this research is to investigate building personas for dogs within the context of screen use from questionnaire data collected from owners on their dogs. Within this goal, further goals are set to build a storehouse of data on dog information and from this a useful set of personas. From these, research questions arise:

- How do you make personas for dogs?
- What changes are needed in method transferal of persona methodology from HCI to an ACI instance?
- What can these personas tell us about dogs' use of technology?
- How do we measure usability and validity of ACI personas?

4.2 Related Work

In recent years, the way in which researchers work with animals in science has changed. It is no longer about what is lawfully ethical with animals as research instruments, in a cost-vs.-harm scenario (Väätäjä & Pesonen, 2013; Chapter 3). Instead, it is now a progressive stance of valuing the animal, as illustrated in the welfare-centred ethics framework of Mancini (2016) as a research participant. Against this background, of increasing ethical and societal stance, the approach of designing in an animal-centred way has emerged as a key theme for ACI. This is not just about making the animal involved in the design, but is also a philosophical stance of acknowledging the direct and indirect entanglements that we, as humans, have with other species and organisms (Haraway, 2008). This is important when the animal is the direct user and the indirect user (Weilenmann & Juhlin, 2011).

Designs of these new animal-centric technologies have typically emerged from the perspective of the human technology designer who has a vested interest in the technology solution—often guessing at the animal end users' needs. As a result, often the animal end user is only involved in the technology towards the latter stages, such as user testing when the majority of the systems options have already been designed. Less studied is co-designing with the animal from the onset, primarily due to there being a lack of methods to involve this specialist end user and a debate within ACI around the ability to co-design. As such, effective methods to help ACI system designers during the conception phase of technology are still in their infancy.

Challenges for ACI are not only in understanding the specific animals' technology relationships but also in designing methods and tools that allow the study of these different animals (Asplin et al., 2015).

Frameworks to aid this understanding have been constructed for ACI technology in interaction design (Spool, 2016), ubiquitous computing (Mancini et al., 2014) and games design (Racca et al., 2010; Westerlaken & Gualeni, 2014). Some of these aim to reveal the role that technology plays within a human-animal interaction (Mancini et al., 2014), whilst others aim to minimise the human role to more fully design for the animals' unique needs, such as the work within this thesis.

Current personas created within ACI, by Robinson et al. (2014) and Frawley & Dyson (2014), are scenario based. When ACI researchers design systems, an ethnographical approach of limited studies, broken down into species as appropriate, is often merged with knowledge of animal behaviour and design experience. Whilst this is helpful, it typically does not focus the designer on the needs of the animal end user within the specific context. This need to represent the animal as an individual is often employed in animal shelters where dog characteristics are listed to help the animal carers to better understand the dogs' needs (Figure 17). Perhaps in this way then these Personas represent a mid-ground of use practice within HCI and ethology.

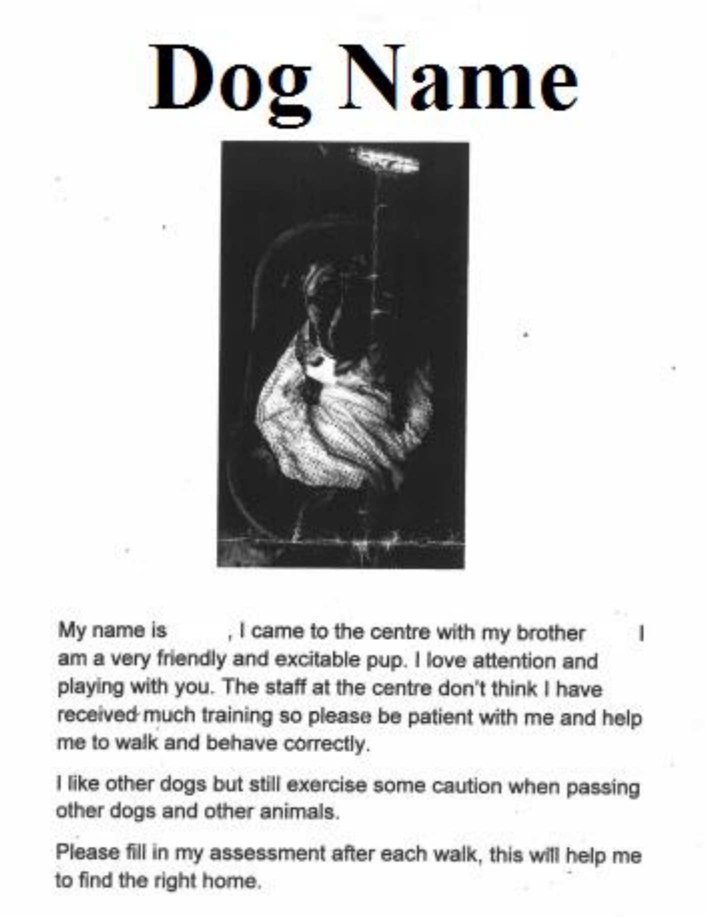


Figure 17: Example of the information sheet put on the dogs' kennels in the RSPCA shelter involved within this work. Names have been removed to protect the dogs.

4.3 Previous Personas in ACI

Within ACI, there have previously been two instances of personas (Robinson et al., 2014; Frawley & Dyson, 2014). Robinson et al. (2014) explored making scenario-based personas for assistant diabetic dogs for a particular application. They also explored making a partnership persona to interlink the dog and the dog owner. The personas were based upon patterns the research team had observed in a fictional perspective manner (Robinson et al., 2014). The personas included a description containing quantitative and qualitative data such as age, breed, good with children, travel habits, etc., in a paragraph descriptive format (Figure 18).

Dottie (Fig. 2) is a medium-small, five year old terrier-type mixed-breed assistance dog. Her job is to warn her owner, who has Type 1 Diabetes, if the owner's blood sugar levels are going too low. Dottie goes everywhere, including planes, with her owner. She avoids all other animals, unless they are dogs she already knows well. Dottie isn't too keen when her owner's children have made high-pitch noises and gets very worked up when she hears a neighbor's cat screeching. Dottie isn't especially playful with toys, but loves running around in circles at high speeds outside. She is shy in new situations and her owner has noticed that Dottie is less likely to warn him about his dropping blood sugar if they are in an environment with a lot of distractions or unfamiliar faces.

Figure 18. Robinson et al.'s (2014) personas paragraph

In presenting these personas, Robinson et al. (2014) emphasised the need to include size, attitude and play behaviour. Mirroring the positions of Grudin & Pruitt (2002) and Pruitt & Adlin (2006), ACI personas' work emphasises the need for the persona method as a complementary method where the personas are a reference point (Robinson et al., 2014). In terms of usefulness, Robinson et al. (2014) found personas useful in demonstrating to designers of ACI systems and other disciplines the needs of the end user but concluded that, going forward, ethnographic data (quantitative and qualitative real data) should be used to create richer personas based on real animals, to assist ACI designers. Frawley & Dyson (2014) created goal-directed chicken personas for an agriculture egg-laying farm (Figure 19). The information that fed these personas was obtained from interviews with the farmers and with observation of hens in both commercial and suburban (backyard) settings. In this way, they perceived the personhood of the animals (Milton, 2005), whilst admitting that the persona created is a human and semiotic artefact, gaining a more human understanding of the chickens.

Name:	Betsy
Age:	12 months
Breed:	ISA Brown
Lives:	In a mobile hen house in the New South Wales' Southern Highlands, Australia.
Betsy started laying eggs at about 6months of age and is working at laying 1 egg a day, although on a good day she'll sometimes lay two. She wakes up at dawn and takes herself to bed at dusk. In the mobile hen house there are 300 other ISA Browns all of whom lay eggs, and scratch around the field during the day. She has a curious disposition and if doors are left open she'll go in and explore. She once got into the farmhouse. To allow her to move around safely the farm has several large Maremma dogs- that are trained to guard her and the other girls. Though as a pullet she found the dogs scary she is now used to their presence on the farm. She likes green vegetables and has several times broken into the vegetable patch when the electric fence was turned off. She enjoys being around the human farmers and doesn't mind being picked up- in fact there is a spot under her chin that she quite likes having stroked. However she is soon eager to be back on the ground with the other chickens, eating, pecking and taking dust baths in the dirt under the trees.	

Figure 19. Frawley & Dyson's (2012; Table 1) personas for chickens

To reinforce this perspective, Frawley & Dyson (2014) used the third person to remind the reader that this is an outside perspective on the chicken. The personas were used as an evaluation tool, and they were useful to highlight the tensions between animal welfare and a system that creates animals' death (Frawley & Dyson, 2014). In this way, the persona tool was used not only as an exploration of assumptions and stakeholders' interests but also as a reflective tool (Frawley & Dyson, 2014). This work builds incrementally from the two previous instances for ACI personas for both improvement and to create a specific set of personas for dogs use of screen systems. The difference within this work from Frawley & Dyson (2012) and Robinson et al. (2014) is both a varying set of personas and the specification of the dog screen focus.

4.3.2 Dogs and the Design of Media

Dogs can take on different roles within ACI as working animals (Mancini et al., 2015), playful interactors (Pons et al., 2015) and supporters of human roles (Frawley & Dyson, 2014). These different ACI animal functions have different objectives and roles within systems with the animal presenting different behaviours towards different instances. As these systems have different objectives and roles, personas that are associated with a single role should be developed. In the present work, this role is of the dog as a playful interactor, and the specific interest is in how the dog interacts with technology and specifically with screens that are displaying media. Through exploring dog personas, it is hoped that a useful tool can be created for DCI designers to use, among a skill set. These will be based upon real data gathered from the dogs' owners through questionnaires and then correlated into usable persona sets. This work, like what Frawley & Dyson (2014) found, is hoped to open a discussion around understanding animals and their entanglements whilst creating usable tools for DCI designers in media technology.

4.4 Creating Personas for Dog-Media Interaction

4.4.1 Methodological and Philosophical Choices

As demonstrated above, fictional perspectives and goal-directed perspectives have been used for personas in ACI. Here, a role-based perspective is used for its focus on behaviour (Cooper, 2014), and given that it is data driven, it is able to bring much-needed clarity and consistency to ACI, allowing a relationship to form between the data and the persona description (Nielsen, 2016). This persona method fits with the ACI's animal-centric approach by, even if by proxy, centring the design around real data. The engaging perspective was not used as it moulds the mental image of the users together with typical and automated acts (Nielsen, 2016), opening possibilities of implicit assumptions and, particularly with animals, anamorphic viewpoints. Similarly, fiction-based perspectives were not used to avoid extreme characters (Djajadiningrat et al., 2000). The inclusion of owners within the creation of personas, to elicit as real data as possible, minimalises the human and semiotic artefacts that all ACI designers face (Frawley & Dyson, 2014) but is wholly impossible to exclude due to the proxy nature of the process. In addition, the use of third person linguistically, as in Frawley & Dyson (2014), will remind the designers of the third person perspective.

Of interest for the research were two main user groups: dogs currently situated in people's homes and dogs in rescue centres (kennelled). The two were chosen as they potentially have different requirements and needs (Marinelli et al., 2007), which will be reflected in DCI media system requirements. Another grouping of the data was within breed as it has been found that breed and type affect the behavioural components of the dog suggesting considerable genetic contributions to the behaviour variations (Sundman et al., 2016). The last grouping was by age as both the behaviour and physiology, such as vision, hearing, smell and musculoskeletal changes, can change the dogs' requirements and thus the personas (Starling et al., 2013; Seksel, 2017).

The context of this work is to aid in the development of screen systems for dogs watching media by crafting personas for screen DCI to aid designers in focusing on and better identifying the requirements of the dog user. Whilst systems have been constructed to support dogs (study 2 [Chapter 7]; Zeagler et al., 2016), these are often based on individual (as in a single dog) dog requirements. This work seeks to aid this endeavour by supporting the overarching goal of improving usability with screen devices for dogs.

This study has four stages: (1) designing questionnaires and personas, (2) data gathering, (3) encoding into personas and (4) validating personas. The method used here draws on existing methods in HCI and ACI towards DCI. The method implemented to design personas was to first research and create questionnaires based upon our previous research held within this thesis about dog requirements in ACI. These questionnaires were then piloted to allow improvement through iteration. Once these tools were developed, a method was made to encode the data gathered into personas with dog owners for the first user group and the kennels contacted for the second user group. The method section below describes these processes in further depth.

4.4.2 Questionnaire Design

Questionnaires were chosen to elicit information from the dog owners/caregivers, as a source of habitual and familiar information, but there are other approaches of data gathering for personas. Cooper et al. (2014) suggested observational market research data which in ACI's case could be explored by observing dogs using screen technology to form the data for the study. This approach is not used in the present study. Instead, the questionnaire approach is taken due to wanting to gather information about the dogs' environment and wanting to collect as much information as possible. Another data approach that could provide valuable data is third-party reports (Wang, 2014), such as those by companies that make dog screen products. However, these were not available.

Moser et al. (2011) found three different approaches for questionnaire design; qualitative, quantitative and a mixture of the two. Cooper (2014) initially used a qualitative approach to get behavioural information and identify behavioural patterns, whilst other researchers have used qualitative data through cluster analysis to find context patterns (Failey & Flechais, 2011; Miaskiewicz, 2011; Moser et al., 2011). Referring to Moser at al.'s (2011) decision diagram for special users, the present research presumes partial pre-knowledge (ethnographic data from other studies included within the field and research), the skills of the researcher and available users, >100 sample size and the availability of resources and time. This leads to the conclusion of using a qualitative and quantitative approach to the questionnaire design.

Taking reference from Robinson et al. (2014) and Frawley & Dyson (2014), demographic information such as age, gender, breed and if the dog was neutered was gathered. Whilst age and breed have been shown to influence the design of technology for dogs, there has so far been no differentiation shown, in gender and neutered status in technology entanglements, unlike HCI (Marsden & Haag, 2016). However, studies of animal behaviour have shown some differences along these lines (Sinha, 2003), so they were included. In addition, previous persona designers (Grudin & Pruitt, 2002; Nielsen, 2016) stress the importance of creating a narrative among the personas to compose them as realistically as possible. Thus, as this is how dogs are talked about, this information was gathered.

Qualitative questions made up the bulk of the questionnaire. These included questions mentioned in Robinson et al. (2014) about temperament with children, places the dog had access to and toys the dog had. An open-ended question was also given about the generalised behaviour of the dog to gather as much data as possible. Asking about walks and the frequency of walks gave some insights into the activity levels of the dog and of the relationship of the dog with the owner. It also possibly teased out information about routine. Questions were raised around the technical devices and equipment used by/around the dogs, centring around media technology to create scenario-based personas. This aimed to enable designers to form a picture around what equipment a dog has ordinarily to help them design around commonplace devices. To aid in this formation of a picture of a dog, a question was asked about the dog's background. The majority of questions centred around the dogs' motivation as, for a dog to use a system, without training, it must be motivated to do so (Zimmerman et al., 2007). Asking the owners to specify their dog's favourite time of the day also gave insights on the type of dog – active or restful perhaps. The last question was an open-ended question that allowed owners to add anything they saw as important in DCI media systems. The same questionnaire was used for both at home and rescue dogs.

In choosing which characteristics to include – the main aim was to gather behavioural data in relation to the dogs' preferences, its attention to and relationship with technology and its general temperament. Understanding the dogs' environments within their homes was required as the basis of personas is that each is a whole description of a 'user' and thus where the dog lived was important.

4.4.3 Questionnaire Administration

The questionnaire was piloted before use when it was found that the participants, ordinary dog owners, were not all aware of the ACI field and, as such, often got confused around questions about their dog's use of technology (TV, iPads, radio, etc.). To counter this, a participant information sheet was designed that gave an introduction on the purpose of the study and the ACI field. It was also found that the additional comments section of the questionnaire was used for suggestions for technology that the owner believed their dog would benefit from. The final questionnaire used is available in Appendix 1.1. To reach a large audience for 'at home dogs', the questionnaire was put online and advertised through the university, on the researchers' own website, via Facebook dog groups and on dog forums. This was for two months, over March and April 2016. Over 250 online responses were initially recorded. To reach kennelled dogs, the researchers visited the kennels in February 2016, where the staff filled in paper-based versions, on four dog participants. An example of the data gathered through the survey is given in Table 1. The full set of data can be viewed in its entirety in Appendix 1.2.

Age (Months)	280 months
Breed	Irish terrier
Neutered	Yes
Good with children	Yes
Does your dog go on walks	Yes
Frequency of walks	Every day
Dog's general behaviour	Loves people, hates dogs, chases balls, sticks, cars if we are not careful, typical of the breed
Background	Purchased from Irish terrier breeder aged 4 months.
Places the dog has access to	Whole house and garden, plus woods and fields on walks
Is the dog involved in work?	No
Devices the dog currently uses	Leads, balls, sticks
How long does the dog spend with these devices?	He would spend all day chasing through the woods if we let him to the point of collapse! In reality half an hour a day is enough at his age.
Does the dog use any technology devices?	Loves to watch dogs and ball-based sport on TV
How long does your dog spend with these devices?	Never on his own, joins us to watch TV at night
Motivation	Chase instinct, defending human pack/property, FOOD!
Favourite toys	Balls
Any specialist needs	There are no special needs.
What part of the day does the dog most enjoy?	Morning walks
Additional comments	No idea really but his breed needs human contact.

Table 1. An example of the raw dataset gathered from dog owners for 'at home dogs'.

4.4.4 From Data to Persona

Most of the data that were gathered were from owners in the United Kingdom, Canada, France and the USA. An RSPCA centre was involved in the collection of data for the kennelled dog personas. Data were collected in April–May 2016. The study was participated in by 196 dog owners, with the dogs ranging from 2 to 192 months (2 unknown) of 114 different breeds and mixes (excluding crossbreeds 49 purebred dogs). Eighty percent of the dogs were neutered. There were 22 dogs that were involved in a form of work (from agility sports, blood giving, explosive detection, service dog, etc.).

Within the data, there were instances where the dog owner did not understand the question, or believed the question to be unintelligent, such as 'why would a dog use computers' written by owner 62. To avoid confounds caused by partially completed questionnaires, the contributions from any dog owner who failed to complete two or more fields within the questionnaire were excluded from the study. This left 196 sets of useful dog data for the persona-creation process (see Appendix 1.2).

Having decided on the useful data, there was a need to do some cleaning and encoding before the data could be used to generate the personas. Examples of cleaning included ensuring consistency of words so they could later be analysed using clustering software. Sometimes words meant the same thing but were written differently, such as mutt or crossbreed, ages were written as months and as years, names were mixed with capitals and lower case (Akita vs. akita), etc. Through the data, breed names were changed to standard Kennel Club breed names, ages into months and crossbreed used in place of mutt/mix and other terminology used to imply an unknown specific breed. For analysis, narrative like the number of daily walks was encoded to a numerical representation with 'not often' being mapped to <=2 times a week and rarely to <=5 times a month (based on words and numbers from other data entries). Around 250 data points were thus tidied up across the data.

Age encoding was additionally found to be problematic as different breeds of dogs reach maturity at different ages with sexual (6–9 months) and social (12–18 months ending at 24 months) maturity being reached at different times (Overall, 2013). To enable both sexual and social maturity to have been fully reached, and so considering a dog to be adult, the data were cleaned to show all dogs over 24 months as adult dogs. Similarly, whilst most vets consider dogs of 7–8 as senior, smaller dogs are often not considered senior until much later (10–12 years) (Overall, 2013). For this reason, the data were coded in such a way that all dogs that were over 96 months were coded as seniors. In this way, it was possible to cluster the data for puppy, adult and senior dogs and thus use those clusters to generate personas for those 'ages' of dogs. This age clustering could also be done through first clustering the dogs' size through classification and then further grouping the data by age. However, this system is made more complex through further defining breed size in dogs which are an indefinable breed, as such was left with the above grouping.

A second categorisation of the data was along breeds. Due to different types of dogs having different breed characteristics, known as 'Breed Standards' in the Kennel Club (2016), it was assumed that their abilities along with these traits would influence their interaction with media DCI technology. The Kennel Club clusters breeds through seven traits, which are gun dog, hound, pastoral, terrier, toy, utility and working. A decision was made to focus on the most common traits in regard to breed descriptions. According to Kennel Club breed registration figures (2016), Border collie and Labrador retriever breeds are the most popular. These two breeds could also be considered 'instances' of pastorals (Border collie) and gun dogs (Labrador retrievers). The other five breed traits were not represented in personas within this instance due to the two chosen instances having a higher data set thus representing the breed more accurately. In future iterations, these other breeds could be further represented.

Dogs in rescue situations, such as those in kennels, had different requirements and access to different technologies than those who lived with owners. Research from Topal et al. (2012) analysing dogs' behaviour, currently homed but from a rescue situation, revealed that these dogs displayed the same behaviour as a dog that has grown up with its owner. For this reason, dogs from previous rescue situations were not separated from those that had grown up with their owners, and only dogs in current rescue situations were considered in this category.

Thus, to create a set of personas along these categories, the data were grouped into three categories—age (puppy, adult and senior), breed (Labrador retriever and Border collie) and living situation (rescue)—and analysed through keyword and phrase analysis using NVivo software to give numerical frequencies of the phrases and words. The most frequently used words and phrases within each question for each category formed a theme of concepts which were then used within the persona. This word 'clustering' was achieved by selecting the most frequent words and phrases of the desired data within the question. For example, in 'favourite toys', 'tennis balls' was the overall most popular so it would be input into personas or 'gender' to form the gender of the dog. This same process was taken for numerical data where the median was represented. In this instance, the persona directly represented the majority of users' thoughts within the selected categorisation.

The presentation of each persona was designed to include a picture, a name and a direct quote. The visual design of the personas was chosen to be clean and simple to allow for easy interpretations. This was due to recommendations made by Nielson (2016) for clarity within personas. Eight elements were chosen to capture the dog's individual traits / behaviours / situation as shown in Figure 20. The areas the dog had access to are listed as these give an idea of the home of the dog – clearly if a dog was only able to be in the kitchen in a house and not a living room then this could influence screen design. This section also allowed for outside areas to be listed. The section headed behaviour collected behavioural data in bullet points. This mirrored some of the ideas that are seen in the animal centre narratives and is a common section in personas as it paints a picture of the individual dog. The background gave a historical account – this was important to perhaps show where a dog might have had a different background also whether a dog was new to a family. This might have implications for familiarity of the dog with technology and with space. Interactions gave some insights into the sociality of the dog and the 'size' and 'shape' of the family. Here it would be clear if there were other dogs, small children or interesting objects in the house – these being elements in the space (Haraway, 2010). Similarly toys and devices gave elements in the space. The dogs' motivation was chosen to be shown on a scale based around a cluster analysis of phrases and words used within the results, giving the DCI designer a useful visual representation. This was considered to be quite important in design terms as it would highlight perhaps how to build attractors into any system and how to design feedback. Technology had and wanted was more aspirational and gave some ideas about how the owner viewed what would be beneficial to their dog, again giving some insights into the individual dogs. The personas' names and pictures were fictional details to enable the persona to be more concrete and effective for design (Cooper, 1999), giving a sense of realism to the dataset. This persona template was therefore designed specifically for this scenario (Figure 20).

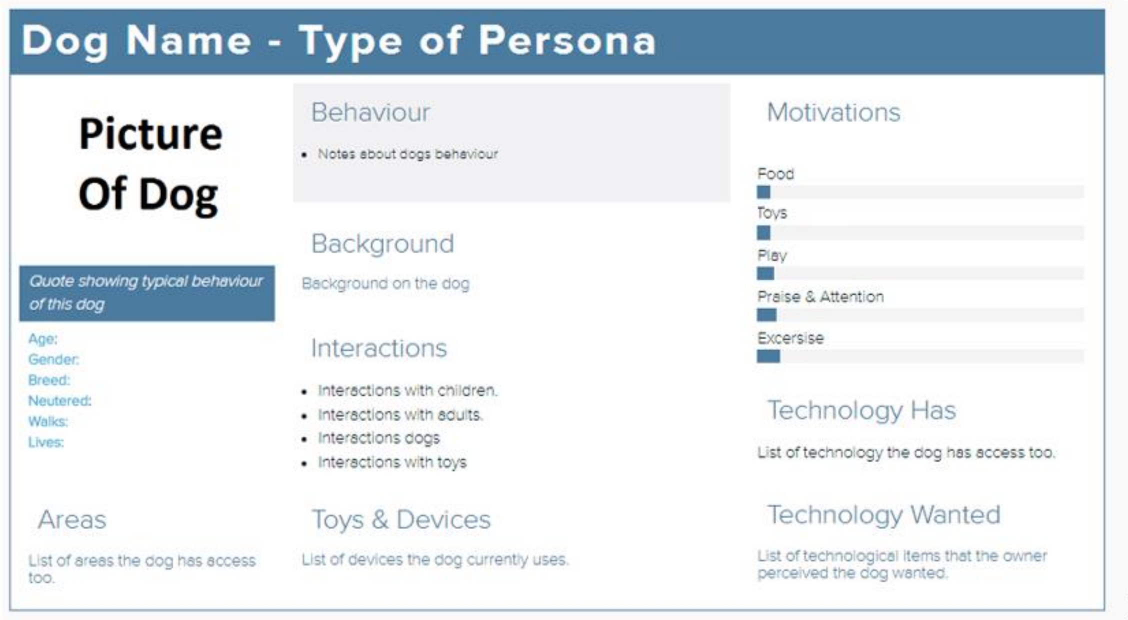


Figure 20. Persona template used for DCI with media personas

4.5 Personas

Fourteen Border collies were included in the making of the breed persona Border Collie (Figure 21) and twelve Labrador retrievers included within the Labrador persona (Figure 22).

Figure 21. Border Collie Persona

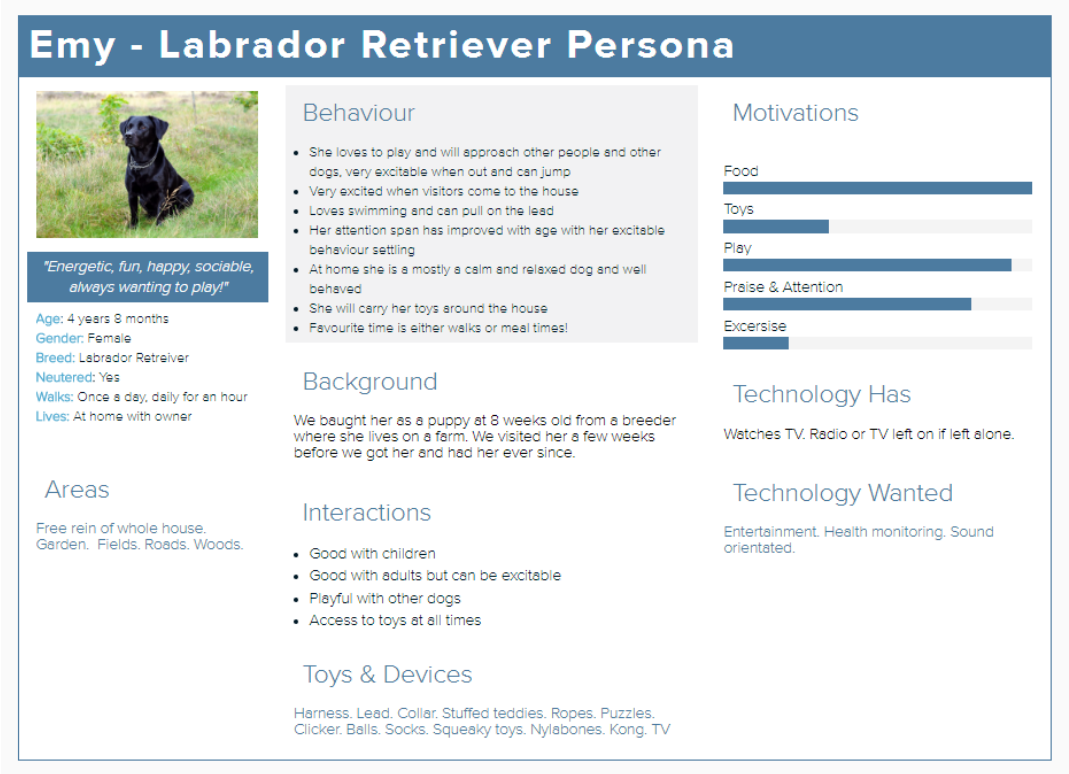


Figure 22. Labrador Retriever Persona

These are slightly lower numbers than expected due to the breed variances and the mixture of breeds being present within the dataset. These two breeds, however, were the most present within the data. Twenty-eight puppy dogs were included within the puppy personas (Figure 23), one hundred and ten within the adult persona (Figure 24) and fifty-four in senior dog personas (Figure 25). This demonstrates a bias in the data towards adult dogs, suspected due to the largest age range of the three categories. These personas, however, had a larger dataset of creation and as such are more applicable than the breed-based personas towards generalisation.

Figure 23. Puppy Persona

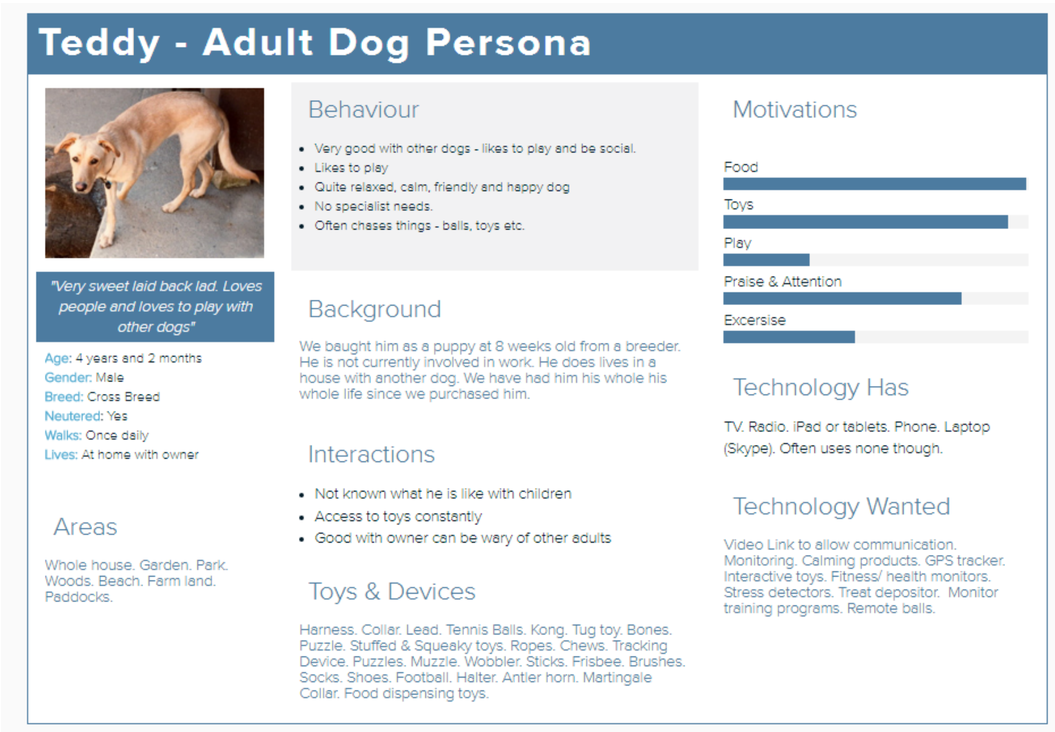


Figure 24. Adult Dog Persona

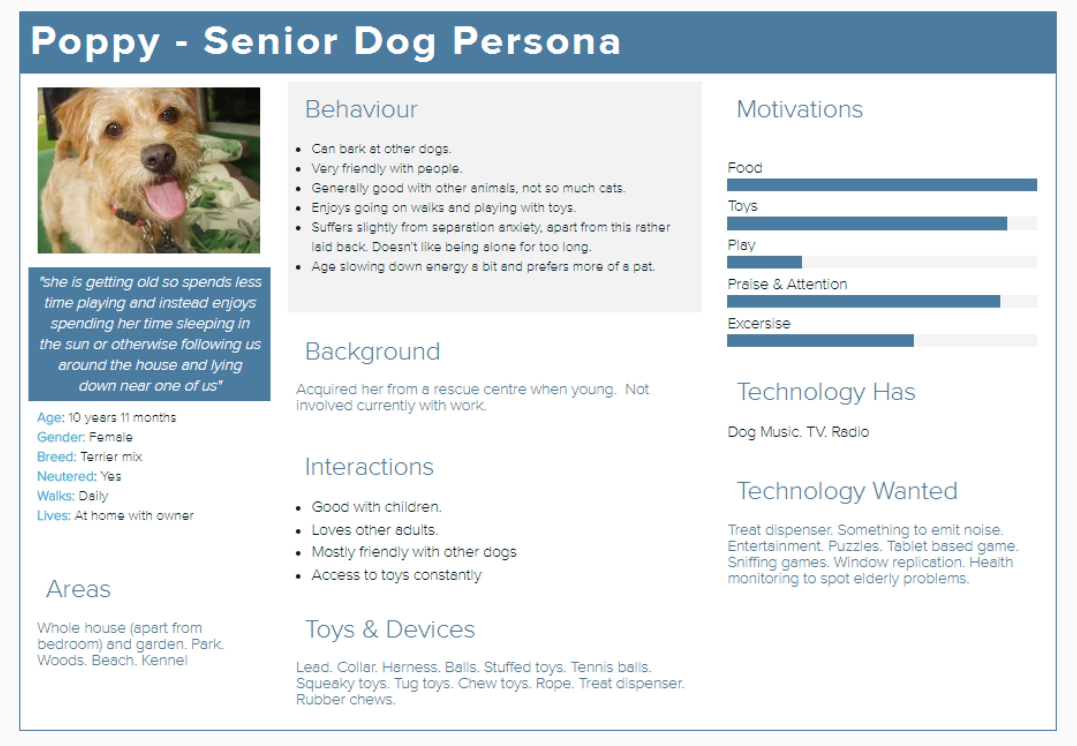


Figure 25. Senior Dog Persona

Figure 26. Rescue Dog Persona

Four dogs were included within the rescue personas (Figure 26). These low numbers were due to both the workers' familiarity of the dogs and the diminutive information known about those held. This is reflected within the rescue persona created being sparser than the home dogs. Uniquely, unlike the other personas that preferred food and toys often, the rescue dog persona has the motivation of praise, attention and humans along with constant mention of the need for human interaction within the data.

4.6 Persona Validation

Personas in HCI are known to be notoriously hard to validate without continuous iterations through product development. One way of validation, as used here, is to build the personas through a process of data-driven development (McGinn & Kotamraju, 2008). Personas have been checked for their usefulness through measuring their attributes (Chapman et al., 2008). In Chapman et al.'s (2008) work, they found that the number of attributes added (n2 ideal) decreased the prevalence rates towards the end user, stressing the need for assessment. It was under this guidance that the personas created were precise with minimal attributes added. Gross et al. (2009) suggest that at various stages of a persona development process, reconnecting back with the stakeholders through interviews provides a method of continuous persona validation. This is problematic within ACI where the dogs can hardly comment on their personas. However, other stakeholders in ACI, researchers, can be a useful group to validate the personas created.

To that end, researchers in ACI were contacted and given the persona set and asked to comment along the following questions: (1) Do you, as an expert, see any room for improvement? (2) Would you find personas like these useful? (3) Is this set of personas a specific set? (4) Are these personas efficient? These researchers were chosen as they had previously worked in ACI studies specifically with dogs and screen technology following Tory & Mollers (2005) guidelines of using expert reviewers for evaluation. The questions asked were intended to seek ideas for improvement (1), and thoughts on usefulness (2), competence (3) and efficiency (4). Seven ACI researchers took part in this evaluation: four with a background only in ACI (A, C, D and F), one from mainly an HCI background (B) and two researchers with an animal behaviour background (E and G) (Table 2; Table 3).

Expert	Research Background	Expertise	Experience in ACI (out of 5)	Years in ACI	Publications in ACI
A	Animal-Computer Interaction	PhD student in Animal Computer Interaction with a background in HCI wearables and industrial design.	5	2	6 papers and journals.
B	Mainly HCI recently moved to ACI	PhD in Information Technology interested in Interaction Design, HCI, Wearable Computing, Mobile AR and NUIs. Associate Professor.	4	1	4 papers
C	Biologist moved to Animal-Computer Interaction	PhD in ethology currently working as a university researcher into dog behaviour	5	4	6 papers
D	HCI moved to Animal-Computer Interaction	PhD in Human-Animal-Computer Interaction, worked in tech start-ups and expert in UX/UI.	5	3	10 papers and journals.
E	Mainly Animal Behaviour recently moved to ACI	Certified international trainer and behaviour consultant and master's student in Human-Animal interactions.	3	1	1 paper
F	Animal-Computer Interaction	PhD student in Animal Computer Interaction specialising in interaction and game design.	4	4	9 papers
G	Mainly Animal Behaviour recently moved to ACI	PhD student in Animal Computer Interactions specialising in wearable devices.	4	2	2 papers

Table 2. Table showing DCI researchers' comments on validating personas

Expert	Experience of ACI (out of 5)	Comments
A	5	Thought the personas were useful and can be used as a great tool for both new people in the field and experienced researchers working with various animals. Wondered if there were any trade-offs to the personas for behaviour and technology and what other breeds might fit into each persona as this might be helpful for researchers in DCI design. Suggested changing the technology wanted section into a bar chart to classify different technologies but did like the current layout for its detail, but this did dilute trends. Lastly, the researcher questioned the amount of time of each dog exercise to help with durability and robust-ability of DCI products. Overall found to be a good survey of pet dog; did note that abused or behavioural sensitive dogs were missing, hinted at in rescue personas, from the set.
B	4	Thought the personas were nice. The researcher would have also wanted to include the category of people in diffractions (new/known/favourite), as this affects the general behaviour of the dog when there are those motivators/influences and/or interactions. The researcher did state that the personas could be improved through a section about problem behaviours and if the dog has a limit to the number of dogs within this environment. She stated these personas would be more efficient if there was a history of what was already tried/successful and add some recommendations made upon these. Lastly, the researcher suggested putting these online and opening them up for comments to enable a joint expertise to form.
C	5	The researcher thought this set was useful, particularly as a template for different ACI scenarios but would benefit from having how dogs currently use technology (paws or nose) along with levels of excitement. This expert also asked if this tool was just for designers or also dog owners, as she suggests a tool like this could also be used by owners to raise awareness on both the owners and designers about good and bad practice.
D	5	The researcher stated these personas would be helpful for someone to broadly gain a picture of what designing for dog's entails, dog differentiation and some key things they should consider. Suggested adding in what kind of work/job they have and what this entails as there is often confusion in DCI over this.
E	3	The researcher suggested personas to align with current 'personality' assessments literature in existence to improve such as Dog Personality Questionnaire (2016) and C-BARQ (2016). The researcher stated as a designer, she would like more questions on the parameter of the animal such as sound sensitivity, tendencies towards light, OCD and focused behaviours, mouth or paws use, dog arousal and confidence level. She then suggested these could be tested through rating different toys/interfaces, ratings for the dog and then a measure of compatibility.
F	4	The researcher believed these personas are good in inspiring a designer's design process. However, the researcher felt that when using personas, something is lost within the design relationship between the dog and the researcher. This researcher felt that when a dog is not available though, these personas could be useful with a combination of methods.
G	4	The researcher felt that the technology wanted field is not consistent with what animals really want but instead by the owner and suggested instead that there should be a distinction between what the dog wants and what the owner wants. In this way, this researcher felt it would help the designer understand that the dog can be a user. This researcher did find the toys and devices field useful for designers and overall liked the personas.

Table 3. Table showing DCI researchers' comments on validating personas

These researchers found the personas useful with the main suggestions for improvement being around interaction modalities such as paws or nose (C and E), more information around behavioural reactions (A, B and E), more about the dogs' work (D) and more on people/dog interactions (B), and they wanted a separation between technology that the owner and the dog wanted (G). Overall, the experts agreed that the persona set would be helpful, with comments made about the set being available online for open forum comments (B), as a template (C), as a tool for dog owners (C), as a design guide (G) and as a research tool (F). Questions were also asked around trends spotted in the data gathering process (A). Some researchers did state their preference over working with dogs themselves (F) but did recognise this persona set could be useful to help inspire designers. Whilst suggestions were made to separate the dogs' and owners' wants (G), this separation would be hard to distinguish from the owners' own prejudice, but this work does admit to the owners' own requirements influencing the data gathered.

This method of expert validation does have limitations towards this tool's validation as only a few experts were consulted on their grounds of authoritativeness (Table 2) and each would have subjective viewpoints. By consulting stakeholders from various background, it was hoped that this would flag up more confirmations as well as critiques. As the stakeholders were contacted individually, there was no opportunity for them to discuss their views and to work towards a consensus. This would have been valuable. In addition, the personas were not 'tested' in use in a design activity, except for the one carried out by the thesis author, and this is a limitation. As the ACI field grows, resulting in further stakeholders coming into the field, this validation could be strengthened through a larger sample size.

To further validate the created personas, the real-world system of DogTV (2016), a specially made dog TV channel, designed without the personas, was evaluated against the persona set to see if the proposed personas could help with product improvement. DogTV (2016) relies upon the dog having access to a TV device, which all the at-home dogs had, but the rescue dog (Annie) did not; in this way, the persona set would flag up that there is a group of dogs that would not benefit from DogTV. Teddy and Ollie had had access to tablets, so DogTV's expansion into tablets fits in well with the at-home users' technology. Max, with his treadmill and puzzles, might suggest that the DogTV company consider using these toy items to interact with the TV content; Ollie and Teddy might want some radio content, and as the personas suggest, a change in the product requirements with the age of the dog, DogTV could expand its range of videos into age-appropriate viewing to allow variances. It is through conversations, like those mentioned here with the personas on usability of a device, that personas provide the technology, in this instance DogTV, with real-world users' data to help with product improvement.

These expert reviews and real-world systems analysis have not been used exclusively to validate as another scenario of use for these personas as an educational tool to those new into the ACI field for introducing and discussing different dog requirements and needs. These six personas created have been used successfully and been found useful to initially design dog screen systems in a workshop for designing technology for dogs as a way of representing end-users (ATLAs, 2017). This further validates this tool as not only useful to practitioners in the field, but also towards those new to the ACI field and the commercial market.

4.7 Discussion and Future Work

This section discusses the variances spotted within the data during encoding, the tension when creating dog personas between generalisation and individualisation, the use of questionnaire data as a storehouse for personas and the findings from the persona validation.

During data analysis, it became apparent that, as mentioned above, rescue dogs had some very different user requirements compared to those of dogs living with their owners. This amounts to home dogs having their needs for love, affection and belongingness met during their normal home situations, something that is not possible in most rescue instances. Joan (2016) modelled some of this in a hierarchic theory of a dog's needs based on Maslow's pyramid. In Joan's pyramid, called Muttlow's hierarchy of needs, the toys and entertainment aspect is a level above the need for love, affection and belongingness (Joan, 2016). This suggests that DCI technology should not be a main concern for dogs that do not have their underlying needs met. The ACI community should perhaps question the placing of technology into such situations.

The method presented here complements Robinson et al.'s (2014) and Frawley and Dyson's (2014) explorations of personas in ACI. Using cluster analysis, it was found that phrase rather than word analysis was helpful in creating sentence structures that resembled the original data. Clustering was more straightforward the more data were present (i.e. adult dogs vs. rescue dogs) as there were more correlation points. By using correlation, some of the individual stories got lost, and this exposed a conflict of interest between actual representation and generalised representation. To avoid over-generalising, an overall dog persona from the data was not developed; rather, characteristics and ages were presented to highlight the differences within the species, through physiological data, age and location. One issue present within the clustering was the grouping of ages due to different breeds maturing at different ages.

In creating the personas, a storehouse of information was created. This storehouse can be used by other researchers, and grown in future DCI work, to create other persona sets according to the different needs for design. Whilst the current storehouse has a media screen focus, much of the data is transferable and useful to other technology behaviour innovations. For instance, there were a number of working dogs within the study that could be used to make working dog personas. Further data collection could be done to create an expanded persona set from which designers could choose according to their focus—one could imagine a set of puppies and a set of sheepdogs for example. As previously suggested, personas could be correlated against the Kennel Club's 'Breed Standards' to be applicable towards a type of breed rather than an individual breed instance. These personas could also be further developed by doing observations with dogs and screen technology. In this way, the personas would be based upon the researchers' own judgement of the dogs' reaction, the dogs themselves and the dog owners.

The persona set suggested in this study is currently being used in design. This will aid in the further validation of the set in use. Going forward, the usefulness of the personas could be validated to further understand the user's needs, creating further user-centric design stance in DCI, and additional validation could also be done of the personas. This validation could be conducted through observing dogs doing real tasks within DCI to build personas from these instances to base the personas further around a dog seen interactivity as done within HCI (Spool, 2011). However, as the field is relatively new, there are few instances of dogs interacting with technology to base these personas off.

4.8 Conclusion

The research within this chapter presents a set of dog personas, a method for generating dog personas and a storehouse of data being available to other researchers working in ACI and DCI. This chapter explores creating personas for two popular breeds (Labrador retrievers and Border collies) for diverse age groups (puppy, adult and senior dogs) and challenging living situations (rescue dogs). These personas can be used as in the early stage of designing for DCI to help focus the designer on a user which can be inaccessible. This builds on Robinson et al.'s (2014) and Frawley and Dyson's (2014) works, helping to support the persona approach in DCI, thus ACI. Particularly, these personas help DCI in working with media devices as they are scenario based.

Another output from this study is the creation of a storehouse of 196 varying dogs' data to allow DCI researchers to encode their own persona set from these data. In this way, even if a DCI media researcher does not have access to a large population of dogs, the data can help focus the designer on the end-user dog requirements initially. Alternatively, DCI researchers could take the individual dog's data to elicit user requirements.

Lastly, these personas have been validated by evaluating the personas to see if they can improve existing DCI technology and with experts in the field of DCI who would use these personas. Researchers in DCI found these personas useful but did suggest improvements by expanding the set into more dogs with further details about the animal's behaviour. This work also helps to illuminate to DCI researchers that the dogs' physiological (breed and age) as well as living status (pet vs. rescue) has an impact upon the end-user requirements. These personas, however, are an incremental process of refinement rather than a product development phase and could be modified as the knowledge around the DCI and ACI fields grows.

This chapter helps the overall field aims of helping to bring successful interaction to DCI technology for dogs by allowing the conceptual stage of dog computer technology to be focused around the users' needs instead of the later stage of end-user testing. Lastly, this chapter successfully demonstrates the method transference between ACI and HCI, giving guidance to those also wishing to transfer methodologies to grow the combined knowledge, strengthening both fields and HCI ability to design for fringe users. In relation to this thesis, this chapter provides another toolset for DCI screen researchers to use during the initial findings, adding to the embodied methods included within this narration.

4.9 Guidelines Derived from the Study

- Seven personas have been created for DCI varying by age, breed and living situation based upon a storehouse of 196 real dog–gathered data from their owners.
- A storehouse has been created for DCI researchers to enable their own creation of personas.
- This work highlights the difference in dog variances upon the user requirements within DCI systems.
- Evaluating these personas with experts, it was found that they were useful, with suggestions made to include further sections around behaviours and interactions with varying dogs and humans.

Chapter 5

Tool Two: Using Behavioural Information to Assist in the Evaluation of Dogs Responses to Media: Dog Information Sheet (DISH)

5.1 Introduction

Developing a product for a dog requires more than considering the user interface; the product should also fit the user's requirements and context of use (Kujala et al., 2001). With dogs, and other nonvocal users, it remains a challenge to gather these requirements. So far within this thesis, direct methods of tracking behaviour have been discussed (study 1 [Chapter 6] and study 2 [Chapter 7]), but this often has been supported by gathering information (Section 2.7) from the owner regarding their dogs' behaviour as an observer accustomed to their dogs' habitual body language. These owners, however, may provide poor information, as they are habitually not knowledgeable in animal behaviour and as such struggle with descriptive terminology useful for requirement gathering. In ACI, methods of nonvocal requirement-gathering in research with dogs has been ad hoc with many researchers relying on the owner as a proxy to gather requirements.

The growth of ACI research has seen the expansion of systems and methods to mediate human-animal interactions (Väätäjä & Pesonen, 2013), aid playful interactions (Pons et al., 2015), assist in the monitoring of animals (Mancini et al., 2014; Resner, 2001), help owners to care for their animal(s) (Baskin et al., 2015), help assistance animals (Robinson et al., 2014) and improve animal welfare (Carter et al., 2015). Meanwhile, there has been a growth in ACI consumer products that allow monitoring (Petcube, 2016), games (CleverPet, 2016) and even media (DogTV, 2016) for our pets.

In the design of ACI systems, there is a requirement to involve, at least to some extent, the animal end user. It would be preferred if the animals themselves could contribute to the gathering of requirements and also in the evaluation of such products. A significant challenge faced when designing an ACI system, likewise for some human users (Mikolajewska & Mikolajewski, 2012; Burkhard & Koch, 2012), such as very young children (Read et al., 2002), is the users' inability to communicate through the usual channels of vocal or written exchange. In such cases, a user's behaviour can be analysed to indicate welfare (both physical and mental) and to indicate choice and the users' decisions (Dawkins, 2004). To study behaviour, designers of ACI systems have created their own toolbox of requirement-gathering tactics which include interpreting gestures and body language (Baskin et al., 2015), using body/face/eye/gaze trackers (Somppi et al., 2012; Pons et al., 2014; Williams et al., 2011; study 1 [Chapter 6]), seeking physiological signs and vocal behaviour (Taylor, et al., 2014), gathering owner reports (study 1 [Chapter 6]) and using animal behaviourists' opinions (Lemanson et al., 2015).

This chapter contributes in this area of system requirement gathering and evaluation in dog-computer Interaction (DCI) by presenting a tool to increase a human evaluators' knowledge of behaviour to improve the value of human observations of the dog: the dog information sheet (DISH) is a specially designed information sheet showing typical behaviours displayed by dogs particularly when interacting with technology. This new tool in DCI aims to improve the design and testing of dog-computer systems by allowing the dog to be 'more' involved in the design by having their behavioural reactions better measured. Whilst the use of an information sheet to create an informed observer is a generalised idea, it is applied to DCI to see if it brings benefits and, if so, what benefits are brought to DCI, ACI and HCI.

Within this chapter, the DISH tool was evaluated in a study in which half the owners used DISH (group A) and half did not (group B) to compare their feedback of their dogs' reaction to persuasively designed media. The owners' feedback was then evaluated to see if the variability of DISH had an impact upon the qualitative information gathered. The work reported in this chapter was published at *British Human Computer Interaction 2016 (BHCI'16)* (Hirskyj-Douglas & Read, 2016).

5.2 Owner and Behaviourist Reports to Give Interpretations

There are clear gaps within the current methods of measuring an animal's cognition through their behavioural choices via automated or semi-automated technological systems. While new methods are being invented in ACI, such as nose touch plates (Mancini, 2016), one solution is to use the owner or carer of the animal to assist in filling in these method cavities to create a fuller picture. It is this method that this chapter aims to explore.

When observations are made on an animal's behaviour, researchers can only guess, and not ask, what is to be understood from an animal behaving a certain way. To fully understand animal behaviour (ethology), the interpretation behind the behaviour is needed, but this is seldom fully available to an unfamiliar observer. This interpretation goes beyond just labelling the animal's behaviour to explaining why the animal exhibits the behaviour. This scenario shifts when an owner/carer is positioned as an informed observer as he/she will be able to add the missing interpretation from familiarity with, and 'becoming with' through conceptual frameworks, the animal (Haraway, 2010). It is this pitfall of 'becoming with', really knowing your animal as an individual, that animal behaviourists fall into through potentially over generalising behaviour. Whilst all animal species have their own unique communication discourse, both intraspecific and interspecific, that can be categorically determined through description, it can be hard to give meaning to an observed behaviour as the same gestures can have multiple meanings (Miklósi, 2014). This co-constitutive natural/cultural dancing between animals' and humans' needs understanding and synchronicity to derive meaning that is only available to those well-versed in the normal behaviour (Haraway, 2012). This is not to devalue body and gesture behaviour but is to create an enriched perspective through the different levels of understanding (Figure 27).

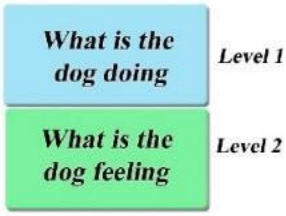


Figure 27. The two levels of understanding dogs' emotions. Level 1: What the dog is doing & the deeper? Level 2: What is the dog feeling?

This is modelled where the interpretation information is only available in Level 2 by fully understanding why a dog is doing an action and not just understanding the action alone. This study aims to push past seen behaviours (Level 1) by asking why, and through what evidence, is the behaviour shown (Level 2). This is an overarching aim to enrich the feedback requirement-gathering process in ACI.

5.2.1 Triangulation of Feedback Methodologies

When designing an ACI system, researchers will often choose methods of inquiry that are supported by, or proposed in, previous ACI or HCI systems. The ideal is to triangulate methods allowing several streams to work together from varying feedback systems, discussed above, to give the best insight into the animal's interaction (Figure 28).

Figure 28. The key method to attaining dog emotions, cognition and the wider interpretation behind the given emotion is a triangulation between physiological signs, the owner and behavioural scientists.

5.2.2 Motivation for DISH

It is this drive to increase the feedback from the (dog) user by including and informing the (owner) observer, that has led to a new tool (DISH) to enhance the interpretation abilities of the observer. This tool aims to strengthen one of the cornerstones of DCI feedback (owner), thus creating a stronger foundation for DCI systems. As the ACI field is relatively new, exploratory studies like this are important to not only put the dog in the centre of the technological system (as discussed within the research philosophy [Chapter 3]) but also lay a foundation for ACI from the person who knows their animal the best: the owner.

5.2.3 How to Measure Reliability in ACI

Reliability, the degree of systematic bias of a method and what quantifies as reliable feedback and methods, needs to be questioned especially with nonverbal users such as those in ACI. Reliability has been considered in HCI through testing the validity of end-user requirements, by testing design and making sure the methods cover a wide range of concepts (Jong & Schellens, 2000; Lambie et al., 1998). The main concern in ACI, similarly to HCI, is, 'Does a method really measure what it intended to measure?'. To answer this, numerous studies must be done through the appliance of concept application across varying scenarios and users. However, the recently established ACI field is lacking this historic application. In addition, unlike with most humans who can vocalise or scribe their opinions, in ACI there is no entirely reliable way to measure emotive opinions against the data for legitimacy. It is therefore an exploratory process to test and evaluate methods continually and methodologically, especially as the field grows richer.

5.3 Dog Information Sheet (DISH)

The DISH is a three-page guide of dog behavioural information largely based on RSPCA (2015) guidelines of dog behaviour and with a qualified practicing vet adding detail to the information. DISH focuses on those aspects of behaviour noted in Baskin et al.'s (2015) study of typical behaviours of dogs using tablets and, from previous work (Section 2.7) and study 2 (Chapter 7), the study of behaviours of dogs when interacting with monitors. Emotions included in DISH are those seen to be held in dogs (Coren, 2015; Miklósi, 2014; Albuquerque et al., 2016). In the DISH guide, dog behaviour is considered against nine emotions, these being confused, stressed, frightened, sick, bad-tempered and angry, anxious and worried, excited and playful. Each section contains pictures of a dog in that emotional state and gives bullet points on typical behaviours to give an overall representation (Figure 29) providing summary guidelines.

Figure 29. An example of the Dog Behavioural Information Sheet (DISH) showing typical behaviour of dogs and given to owners within this study. DISH in its entirety can be found in Appendix 2.1.

The third page of the DISH shows dog facial expressions for different emotions using pictures taken from Bloom & Friedman's (2013) (Figure 29) work that proved that dog owners can generally recognise emotions of their dogs from the face alone. These facial depictions show a dog's face with a range of induced emotions (Figure 29). These emotions included happy, sad, afraid, surprised, disgusted and angry. By including facial and body pictures, as well as physiological and vocal signs, it was hoped to reinforce to the human participants (owners) that behaviour signs demonstrated by a dog are linked to cognitive emotions, thus creating a deeper understanding for the owner of dog behaviour.

5.3.1 Emotions and Dogs

Historically dogs have been considered to be like machines – lacking emotions and being programmable (Cottingham, 1978). Nowadays, some ecologists believe dogs to hold complex emotions, comparing their cognition to a 24-month-old child (Coren, 2016; Topal & Gacsi, 2012). Dogs are reported to be able to recognise emotions in humans and in other dogs (Albuquerque et al., 2016). Modern affective neuroscience backs up these claims (Anderson & Adolph, 2014; Pankseep, 1998), but the study of this field is young, and there are still diverse opinions held within animal neuroscience and behaviour as to what complex emotions a dog can experience.

The analysis of emotions within dogs first takes a biological standpoint of physiology and then a secondary layer of analysis and recognition. Emotions can be registered through different parts of the brain through technology such as positron emission tomography (PET) scanners (National Library of Medicine, 2016). Recognition of emotions has been done in facial expressions both dog-to-human and human-to-dog (Buttleman & Tomasello, 2013). However, the interpretation of signs that convey emotions is subjective and is in accordance to varying degrees to the humanistic view of the dog, be it anthropomorphic, babymorphic or lupomorphic (Topal & Gacsi, 2012). Whilst anthropomorphism does exist under this scope of animal recognition, this is not a reason to elude complex (secondary) emotions, especially when current and historical literature and research supports dogs holding complex emotions.

To structure this work towards dogs' known emotive states, the emotions that dogs do not appear to possess (guilt, pride and shame) are not used within this study (Coren, 2015). In comparison to humans, the emotions that dogs hold are suspected to be of denser but still intricate complexity (Coren, 2006; Drummond, 2004). In ACI, dogs holding varying complex emotions have been widely reported (Baskin et al., 2015; Westerlaken & Gualeni, 2014). Overall, whilst research is unable to say defiantly what emotions a dog accurately has, or even if they are scalable towards humans, this exploration is important in not only understanding dog behaviour but also building up the dog users' requirements, creating better UX.

5.4 Method

This study aims to help optimise the owners' interpretation of the way their dogs react to technology by improving the information that is gathered from owners' observations of their dogs. To see if understanding dog behavioural information could improve owners' responses, a Dog Information Behavioural Sheet (DISH) was developed. The two hypotheses of this study were that

(i) with additional information, owners will provide more useful focused information on their dogs' reactions.

(ii) the information sheet (DISH) would influence the owner's interpretation of the observed (dog) behaviour helping to provide interpretation to behavioural reactions (group A vs. B).

Owners and their dogs were invited to participate in the study. These owners were then paired up with others who had matching dog breeds, to prevent breed-specific behaviours, and consequently split into two groups, A and B. Group A was given the DISH to read before the study whilst group B was not (Figure 30).

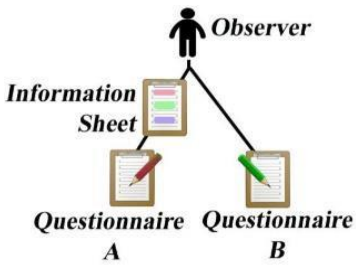


Figure 30. The method of providing only one set, A, of observers (dog owners) with the information sheet (DISH) whilst being evaluated on the same questionnaire. Questionnaires can be found in Appendix 2.2.

Both groups were then asked to watch a two-minute-long video with their dog(s) in their homes and report, during that exercise, on how their dog behaved using a formatted questionnaire. Their answers were then evaluated between groups (A & B) as well as a whole to evaluate the influence of the DISH on owner reports on dog behavioural reactions.

5.4.1 Human Participants

Dog owners were gathered in numerous ways to avoid geolocation differences. The main way of gathering owners was through the researcher's university. Other methods included word-of-mouth, Facebook dog groups and the researchers' website. The dog owners were told of the A/B groupings with an indication that one group got an information sheet (Figure 30) and one did not. They were not told about the contents of the DISH. There were 20 human participants, with a 14-to-6 male-female ratio. The majority of participants came from England, but there were also participants from Israel, the Netherlands and Canada.

5.4.2 Dog Participants

For the dog to participate within the study, the owner firstly had to verify that the dog was fit to participate with no behavioural problems which could influence the study. Following guidelines 6 and 5 from the guidelines presented within research philosophy (Section 3.2.2) for screening for behavioural problems and being mindful and guidelines 4 to have the owner observing. The owner was also told that if the dog had adverse behaviour at any point during the activity and become agitated, the video and study should be stopped: no owners reported this. As some of the dog owners participating within the study had more than one dog, there were more dogs than human participants within the study to allow each owner to have fair treatment for each of their dogs. Such owners were given the option to do the study on only one dog, but all multiple-dog owners chose to include all their dogs. For the purposes of the analysis for this chapter, to maintain research validity, only one questionnaire was analysed in each of these double-dog instances, and this was chosen as being the first data submitted. Therefore, a total of 31 dogs took part in the study, but only 20 dogs' data was considered. As explained earlier, all dog participants were paired with similar breeds to limit effects of breed-specific results. As different dog breeds were historically bred for different purposes, they have different physiological autonomy and psychological behaviour affecting both their reaction to and intake of media (Stork et al., 1995).

5.4.3 Video Formation

The video that was used in the study was specifically designed to induce three nondistressing emotions in the dogs: excited, confused and relaxed. These three different emotions were chosen to see if the owners could identify responses to the emotions in their dog. The chosen video had short clips, attention-inducing sounds (such as toy squeaks and dog barks) and majored on real dog video clips having found that dogs preferred to watch other dogs (Section 2.7). The three emotions were induced through both visual and auditory sound. Classical music has been shown to relax dogs (Wells et al., 2002), so it was used for the relaxing segment along with slow-moving scenery; excited barks and squeaks were used for the excited segment to stimulate the dog and confused dog howls and dogs were used for the confused segment. To stimulate the dogs' emotions visually, a video of dogs portraying the emotion that the video was trying to stimulate were also used, assuming the dog's ability to recognise and sometimes mirror emotions (Schwab & Huber, 2006; Albuquerque et al., 2016). Only real clips (not animated or cartoon) were used, as dogs typically do not respond to cartoon images (Coren, 2015).

5.4.4 Questionnaire Design

The questionnaires for groups A and B were identical aside from the beginning statement reminding group A to read the DISH before completion. The questionnaire was three pages long and split into dog information, owner information and dog behaviour. Dog information asked for basic data about the dog – breed (to help grouping), name (for identification) and age and sex (to check for confounds). Owners were asked to report their knowledge of dog behaviour in a five-point Likert scale (excellent–poor) and whether or not they had done 'dog-training' (assuming this could be a confound). The final two pages of the questionnaire asked questions about the dog's reaction to the presented media. To create clarification, the terminology 'interested' was defined at the beginning of this section to 'refer to the dog having or showing curiosity, fascination or concern'. The owner was then asked how interested the dog was in the video using a three-point Likert scale (very interested/interested/not interested), with a follow-up open-ended question asking the owner how they knew the dog was or wasn't interested. This question was asked to try and get the owners to clarify and expand on their reasoning behind their dogs' (dis)interest leading to a deeper understanding of the interpretation (Figure 27). To illicit the owner to specify key behavioural words, a further question was asked of the owner to report any body language signals. After this, another question was asked of the owner to report overall how the dog reacted and then, as above, what body language signals indicated this. The final question was an open-ended blank- box comment section about their dogs' behaviour to try and capture all the owners' interpretations. Some owners also chose at this point to video their dogs' reactions to aid their memory and to show the researchers for analysis. The full questionnaire is available in Appendix 2.2.

5.5 Results

The study was carried out by the dog owners in their own homes from June to September 2015. Given the low number of participants, the results are explored as a first empirical starting point to validate DISH. The oldest dog to participate was 15 years, and the youngest was 1 year 1 month. The mean dogs' age was 5 years old, with 5 years 6 months being the average in group A and slightly younger at 4 years 6 months in group B. The breed of dogs included within the study were Golden Retriever, Cocker Spaniel, Labrador, Poodle, Jack Russell, Chihuahua, Schnauzer, King Charles Cavalier, Wheaten terrier poodle and Shar-pie.

5.5.1 The Study Sample

The owners' mean knowledge on dog behaviour (five-point Likert) was 'very good' (4/5), with group A reporting a mean of 'very good' and group B having a lower mean of knowledge with 'average' (3/5). Interestingly, no owner rated themselves below average in knowledge of dog behaviour with answers only ranging from average to excellent (two owners rated 5/5). Overall, 45% of dog owners had gone to dog behaviour classes or events, with 50% of these falling in group A and 30% in group B.

Generally, the owners saw the dogs as interested in the video content with group A on the whole being interested (3 not interested, 4 interested and 3 very interested) and B also being interested (3 not interested, 4 interested and 3 very interested). This data suggests that the two groups were essentially quite similar.

There appeared to be no relationship between the age of the dog and its perceived interest in the media. However, the four dogs that were over the age of 75 months (6 years 3 months) were all interested in this video (Figure 31). Given the low number of such dogs, this cannot be considered an effect.

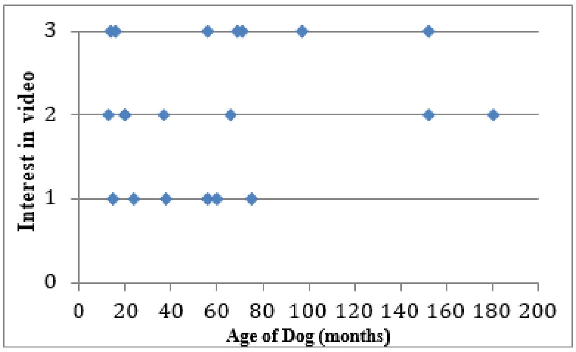


Figure 31. A graph showing the relationship between age (in months) and perceived interest in the media as reported by their owners (1 - Not Interested, 2 - Interested, 3 - Very Interested).

The results are analysed by keywords that the owner mentioned, interpretation given by the owner towards the behaviour the dog displayed and, finally, towards the two hypotheses mentioned above.

5.5.2 Key Word Analysis

To study the open-ended questions, key words of dogs' behaviour, also mentioned in DISH, were counted both totally and within groups (A/B) (see Tables 4–9). As shown in Tables 4–9, although group A was given the DISH and reported a higher confidence in their own knowledge of dog behaviour, group B produced more key words (B had 73 whilst A had 61).

5.5.2.1 Eye and Ear Reactions

	Group A	Group B	Total
Eye Reactions			
Eye contact/looking at me	2	5	7
Eye movement	1	0	1
Wide eyes	2	1	3
Closed eyes	1	0	1
Eye rolling (whites of eyes)	1	0	1
Looking/staring at screen	7	5	12
Eyes focused	0	1	1

Table 4. Table showing number of times owners, split into groups A and B, used key dog behavioural words in relation to eye reactions. Total number is 26: 14 in group A (54%), 12 in group B (46%).

The owners noticed a diverse number of eye reactions reporting them in different levels of detail from ‘looking at the screen’ to the quite specific behaviour of ‘eye rolling’. More generalised behaviours, such as ‘looking’, ‘eye contact’, were reported more frequently than more complex behaviours such as ‘wide eye’, also known as whale eye, when the whites of the dogs’ eyes are showing.

Ear reactions were the most noticed category with a number of phrases being used to describe similar or the same behaviour (Table 5). As ears in dogs are rather emotive, external, and frequently move dependent on their behaviour, this is an easily noticeable trait in the same way the wagging of a dog’s tail is.

	Group A	Group B	Total
Ear Reactions			
Cocking/twitching/pricked pinching/up ears	11	13	24
Ears pinned back	1	0	1
Ears down/pinned down	1	1	2

Table 5. Table showing number of times owners, split into groups A and B, used key dog behavioural words in relation to ear reactions. Thirteen in group A (48%) and 14 in group B (52%): totalling 27 instances.

Nevertheless, mostly owners only noticed the pricking of dog’s ears and not the other behaviours mentioned in the DISH, such as pinning back/down.

5.5.2.2 Facial and Head Reactions

	Group A	Group B	Total
Facial/Head Reactions			
Lifting/raising head	4	0	4
Turing away showing disinterest/looking away	7	7	14
Head to the side/tilted	0	3	3
Disinterested face	1	0	1
Head turning	0	1	1
Facial reactions	0	1	1
Head back	0	1	1

Table 6. Table showing number of times owners, split into groups A and B, used key dog behavioural words in relation to facial and head reactions. Total: 25 instances, group A 12 (48%) and group B 13 (52%).

Owners here noticed a number of different feedback behaviours from the dogs with most owners noticing disinterest or turning away (see Table 6). Group B identified more behaviours (5) than group A (3), but they were described in general ways such as ‘facial reactions’ (group B) instead of specifying the type of facial reaction ‘disinterested face’ (group A) (Table 6).

5.5.2.3 Vocal Reactions

For the most part, owners noticed the vocal reactions from their dogs as their dogs reacted to the dog(s) in the video that were howling and barking (Table 7). Group B reported notably more vocalisations than group A. One owner who noticed that her dog was whining did also notice quite scared behaviour from her dog reporting him as fearful.

	Group A	Group B	Total
Vocal Reactions			
Whining	1	0	24
Howling	2	6	1
Barking	1	5	2

Table 7. Table showing number of times owners, split into groups A and B, used key dog behavioural words in relation to vocal reactions. Total 15: 4 total in group A (27%), 11 in group B (73%).

5.5.2.4 Body Reactions

	Group A	Group B	Total
Body Reactions			
Tail wagging	5	3	8
Walking away	2	4	6
Grab object on TV	1	0	1
Sat stiff/tense	1	1	2
Changing position/turned body	0	3	3
Ran in circles	0	2	2
Froze in position/held ground	2	3	5
Calm demeanour	0	1	1
Sat upright	0	1	1
Skating feet/tapping toes	1	0	1
Approaching screen	4	5	9
Not engaging	1	0	1
Stopped watching	1	0	1

Table 8. Table showing number of times owners, split into groups A and B, used key dog behavioural words in relation to body reactions. Eighteen in group A (43%), 23 in group B (57%), totalling 41 instances.

Body reactions were the most notable behaviour by owners, with approaching the screen and tail wagging repeatedly seen (Table 8). A lot of these body reaction keywords were in relation towards the media such as ‘walking away’, ‘approaching screen’ and ‘stopped watching’.

5.5.2.5 Summary of Key Word Analysis

The most used words given by dog owners were ‘cocking of the ears’ (also called pinched, pricking and twitching) followed by ‘turning away’ and then ‘looking/staring at the screen’. These latter two most noticed behaviours are not surprising as they are concerned with the dogs’ interactivity with the screen which the owners believed to be important to the study: looking and not looking at the media. The most words used were around the dog’s body reactions with, once again, the highest mean mention of words per section being in the ear reactions. This shows that owners are more likely to notice the reactions of the ears as well as reactions to what they perceive the study to be about, in this case media. Owners were less likely to notice specific eye movements, the dog’s facial reactions and demeanour as shown by a score of 1 (Table 4).

5.5.3 Interpretation Analysis

As mentioned before, the behaviour alone needs interpretation to provide more in-depth information. For instance, a dog walking away from the screen could indicate a number of emotional factors from boredom to fear. Some examples of interpretation given behind the emotions within the study were as follows:

‘When the squeaky noises and dogs howling started he raised his head and cocked it to one side (behaviour) as if trying to make sense of the sounds and it seemed to get him excited (interpretation)’.

'She pinned her ears back (behaviour) to show that she was concentrating and assessing the situation (interpretation)'.

To further investigate this, each time an owner mentioned a behaviour in the questionnaire, analysis was done to see if interpretations was given, both through owners individually and within groups (Table 5). As Tables 4–9 show, group A, although using fewer behavioural language words, did provide a deeper interpretation behind the words given with a mean of 74% when compared to group B, who had a lower mean of 44% (Table 9).

Beyond attention – excitement, confusion and relaxation – almost all the owners reported that their dogs were less interested in the second half of the video than the first half. Some dogs did maintain attention throughout, but only two owners unpicked levels of attention in terms of the 'designed in' emotional responses of excited, confusion and relaxation.

This low level of reporting may have been partly due to owners probably believing that the study was solely concerned with measuring the dog's overall attentiveness.

Interpretations Given			
Group A		**Group B**	
Owner 1	89%	Owner 11	40%
Owner 2	83%	Owner 12	44%
Owner 3	44%	Owner 13	25%
Owner 4	100%	Owner 14	36%
Owner 5	60%	Owner 15	40%
Owner 6	88%	Owner 16	75%
Owner 7	60%	Owner 17	20%
Owner 8	60%	Owner 18	50%
Owner 9	86%	Owner 19	86%
Owner 10	71%	Owner 20	20%

Table 9. Table showing number of times owners using key dog behavioural words in interpretation split into group A and B. A mean of 74% compared to B with 44%.

This can be seen in Table 8 with frequently mentioned words such as 'engaging', 'approaching screen', 'walking away' and 'not watching the screen' all being based around being or not being attentive to the screen as opposed to the content on the screen. The two owners who gave more detail were the only two who rated themselves as 'excellent' at dog behaviour and were both from group A (owners 6 and 9). Owner 6 recognised stimulation and confusion:

'Squeaky noises seemed to get excited . . . dogs howling started he raised his head and cocked it to one side and if trying to make sense of the sounds'.

Owner 9 recognised excitement and relaxation:

'In the second half she was less attentive, started to close her eyes near the end . . . the second half seemed calmer'.

This is not to say that the other owners did not notice their dog's different behaviour patterns, but they were not reported. This is clearly a challenge for designers of interactive media for dogs where the aim might be to relax or stimulate a dog – clearly these reactions would need to be observable in any evaluation.

5.5.4 Main Findings

As shown in Table 9, with an information sheet, in this case the DISH, observers appeared to give more interpretation information providing more useful data to help design and evaluate systems. Without the behavioural information (provided in the DISH), the spectator seemed more likely to report body language signals but without interpretation providing less useful data. This shows that the method of educating the informal observer may be suited to be used in nonverbal situations as a technique. In the current study, the mood (or emotional state) of the dog was rarely captured, which suggests that more work needs to be done to facilitate this process.

5.6 Discussion

As joining this study was optional and owners were required to show their interest, there is a natural bias towards owners who were interested in dog behaviour. There was also a bias towards owners who thought their dog watched TV, as many participants stated they did not think their dog would be useful, as they 'didn't pay attention to the TV'. As the study was about the evaluation of the owner's ability to report the behaviour of the dog, it was not a requirement that the dog had to be known to watch TV, and this was stated. As anthropomorphism can occur when evaluating animal behaviour from a human perspective, with pet owners often seeing their dog as almost human (Vaschillo et al., 2004), possibly babymorphic, further questions behind the emotions reported were asked to try to gain interpretation. It should be noted that there could also be owners who were anthropocentric and believed their pet dogs could not possibly understand the media and thus may have dismissed the dog's interaction.

5.6.1 Participant Analysis

Regarding the interest shown by the dogs in the study, no correlation was found between the age of the dog and its interest in the media (Figure 31). All the owners reported an average or above-average confidence about their knowledge on dog behaviour despite a majority of them not recognising (or not reporting) the emotions behind the behaviour. Only 10% of owners noticed two states of behaviour by their dog from the media. Group A self-rated slightly higher than group B in terms of knowledge brought into the study, and their performance on the complex task of interpreting emotions was better (Table 9).

5.6.2 Word Analysis

In Table 1, words that the owner used were analysed and grouped. The grouping of these words is rather interesting, as each owner has their own dialect to describe behaviour, for example, pinches, pricked, cocked, and the like. The words were grouped together when they appeared to be describing the same behaviour; however, each descriptive word could mean a different behaviour by each owner. This issue in future studies could be solved by analysing videos of the dogs' behaviour or by asking the owner further questions regarding their answers. The DISH influenced the owner's reporting of dog behaviour by helping provide interpretation to behavioural reactions (group A vs. B). In keyword analysis (Tables 4–9), participants in group B were able to identify more behaviours than those in group A using DISH. As a group, A gave more interpretations (Table 9), which was what the DISH was designed for, by classifying behaviours in the interpretations of emotions to give a deeper understanding for the expression. This may be the reason why fewer behaviours were given by group A as they were busy providing interpretations resulting in a depth vs. frequency situation. Another possibility is that behaviours were analyses of a whole such as the comment made by an owner of group A vs. B:

> *'Turned away from the TV when showing a scene he wasn't interested'.* – group A

> *'His facial and ear reactions'.* – group B

In these instances, the keywords used would be less, as shown above with facial and ear movement providing two keywords vs. turned away only providing one keyword but still giving further interpretative information. Overall, the number of keywords used evidence that an owner can identify behaviour in their dogs, with a mean of seven keywords used between groups. This shows that all owners are proficient, through observations, in reporting their dogs' behaviour, even at a basic level, regardless of expertise of dog behaviour or previous training. However, there is a direct link between the owners' own confidence with dog behaviour, their awareness of their dogs' emotions, and their knowledge on how they are displayed, even habitually, through body language. This was shown by the two owners (owners 4 and 19) giving extensive interpretation information about their dogs (Table 9) whilst being the two owners who reported the highest level of confidence in dog behaviour. This could be because the owners already have a good understanding of the link between dogs' behaviour and emotional cognitive state. The findings here suggest that the DISH helps give important interpretations behind behavioural reactions, thus improving requirements gathering in dog-computer interaction.

This method also presents a way of correlating DCI behaviour. This provides the important Level 2 (Figure 27) analysis of not only what the dog is doing but also what the dog is seen as feeling. Without the DISH, the majority of owners reported on their dog's behaviour without adding essential interpretation of the reasoning behind the behaviour.

It is not known why owners with the DISH were better able to give Level 2 (Figure 27) interpretive information or why some owners (4 and 19, Table 9) were inherently better at identifying their dogs' behaviour. It is hypothesised this could be due to how long the owner has had the dog (or dogs) or to the empathy that the owner has for the dog. This has been shown in research relationships with humans, where empathy generated through a relational process, with interpreter and participant, affects the understanding of the research enlightening the interpretive information and data (Jones & Ficklin, 2012).

No owner within the study, with or without DISH, was able to identify dog reactions to all the three stages of the video: excited, confused and relaxed. Two of the dog owners in group A (with DISH), were able to identify two different stages of the video linking them to the reaction of their dogs' behaviour and emotions.

Both these owners identified the excited state, which is possibly easy to spot as it is about getting the dog's attention and exciting it with clear behaviour patterns. One owner identified the confused state; the other relaxed. As these owners were in group A and had seen the DISH, they may have had a deeper interpretative awareness. Haraway (2010) writes of this as 'becoming with', which is not just seeing behaviour but also questioning why the behaviour takes place and identifying what this tells us about an emotional state.

Overall, unless the owners are very observant with excellent knowledge of dog behaviour, they are unable to identify different emotions displayed by their dog in reaction to the media. In this case, the DISH does not help, as it does not consider cause and effect. In this situation, unlike the previous one, measuring dogs' reactions to media is difficult.

5.6.3 Limitations of Tool Validation

There are several limitations to this study which can only really hint at the usefulness of the DISH information sheet as there were many variables that impacted on the findings. Firstly, as the study was done in owners' homes, it was not possible to know exactly what went on. It is possible that some owners did not watch the video, even that they did not have a dog! This could have been mitigated against by requiring owners to video their dogs while watching the TV and sending that in with the results – this could also have been useful to validate what they reported about their dogs; behaviours. That said – this would have been an entirely different study and it would have been hard to recruit people.

Making comparisons across the two groups is tricky as again there is no evidence that the DISH information was read and also there was considerable variability between the groups which were small in size, A within groups style study would have mitigated against the differences in the two groups but there would have been learning effects – or the use of purposive sampling in a between groups study could have been useful but again – the complexities of recruitment and the need to know many details to allocate matched individuals to A and B would be problematic. It would still have not been clear if DISH had been read.

Choosing to select the first data for a dog in a two-dog family was defended as this also meant that (probably) the first dog data sent in represented the first time of using the questionnaire however this cannot be certain and one might assume an owner using the questionnaire and watching the TV a second time might have reported different things. Resulting in a possible confound there.

It can be said that the study provided useful data on how owners report their dogs behaviours – especially the findings about how they write their own dialect for dog actions. The use of videoed dog data with interpretations from an animal behaviourist on the dogs' behaviour would have been useful to create a validation baseline.

5.6.4 How to Improve DCI, ACI and HCI

ACI takes areas of HCI and transforms them towards its own needs; this can iteratively be looped back into HCI for peripheral users of systems. Within this work, an approach is taken to try to increase the effectiveness of the observations made applied to a user who cannot vocalise the interaction (in this case, a dog in a DCI system). This approach of owner consultation has taken place in previous DCI studies (Baskin et al., 2015; Lemanson et al., 2015). The goal of this work, to enhance the possibility for the conveyance of dogs' feedback through their owners, is also shared by users of those systems whose designers face similar communication problems relying on a proxy for interpretation (e.g., users such as babies and users with cognitive disabilities). By creating synergy between the two fields of ACI and HCI, a conversation about creative solutions could be opened to empower people and animals as well as the ACI and HCI fields. It is in this way that this work is designed not only to empower animals but also to empower marginalised humans as well. The role of dog owner has been comparable to parent-child relationships behavioural-wise (Topal & Garsci, 2012), with many dog owners seeing their dogs as an extension of family, often babymorphic. Using the DISH methodology, but transferring it to child or baby behaviour, may help gather requirements from those fringe users that require a proxy to gather superior in-depth emotive information as shown here. This method would also work with nonverbal adults in a similar way and could be tailored towards specific known behaviours and disabilities. Regarding HCI, it can be especially useful to have this method of informing the observer, with a tool, when there is a distinct lack of knowledge by the observer or in situations where the user is nonverbal and the observer can offer valuable insight.

Once again, as found here, an information sheet may help here to focus the proxy-observer and empower them through information creating informed observers. This chapter highlights the need to study DCI behaviour within interpretations to better interpret a dog's feedback when using technology and to ensure that the user requirements and experience are better understood. This can be accomplished using the DISH when gathering dogs' emotive responses to media. Whilst it appears uncertain as to why the DISH helps give more interpretations, it does appear to focus the observer to give valuable information from a hard to source subject. Overall, DISH helps enable the observer to have a more serious role within DCI, equipping them for the observation.

5.7 Conclusion

This chapter explores gathering nonverbal users' emotions and interpretative behaviours in reaction to media by empowering an observer through an information sheet (DISH). Evidence is presented how dog owners, as informed observers, were able to identify behavioural signals of their dogs, and how, with the addition of an extra behavioural information sheet (DISH), they seemed to be able to give further interpretive information (33% more) on both the emotion of the dog and on why the dog was displaying that emotion. This interpretation behaviour is important in understanding how a user is engaged with a system. However, across both groups, unless the observer perceived themselves as excellent at dog (or the user's) behaviour, the owners were not able to identify their dogs' emotional reaction to persuasive media (excited, confused and relaxed). This chapter highlights the importance of including dog owners within animal-computer interaction (ACI) studies to help gather requirements and evaluate technology filling in the missing current evaluation gaps in ACI. This work adds both to the ACI field and the HCI field, with the applied method possibly being used for nonverbal or limited cognitive users and on other animals to gather requirements. In this way, this chapter fits into this thesis's overarching aims of providing a method for DCI that is able to be modified from HCI to other ACI animals. This creates a pathway of knowledge from HCI to ACI and thus DCI which could, over time, be iterated back to HCI to help inform both fields.

5.8 Contributions Derived from the Study

- A dog information sheet (DISH) has been developed to create an informed user of the dog's owner in DCI requirement gathering for UX evaluations.
    - Initial evidence shows that when dog owners used DISH to evaluate media, dog owners were able to give 33% more interpretive information.
    - Unless the dog owner perceived themselves as excellent in dog behaviour, they were unable with or without DISH to spot their dogs' reactions to persuasive media.

Chapter 6

Study One: Tracking Dogs' Head Movements

6.1 Introduction

This chapter continues this thesis by looking further into digressing a dogs' interaction with media technology automatically by creating a head position classification schema in MATLAB. This study was conducted with the aim of progressing this human classification schematic into an automated computer-driven device trying to step towards dog-enabled technology. Whilst this is possible, as evident from the findings within this chapter, importantly, this chapter presents evidence of a suitable method of a classification schema can be used for analysing a dog's behaviour. Similar systems have been seen in Mealin et al. (2016) and Pons et al. (2016), who used the Xbox to track body position in dogs, cats and orangutans but away from current technological systems. Whilst this method is not used within the rest of this thesis because of the considerable further work needed to make this system fully functional, it does fit within the story of this work through exploring methods at quantifying a dog's entanglements with screen systems.

Whilst humans inherently use their hands, body and voice to interact with the world around them outside of computers, for the last few decades, and from conception, only hands have been integrated into HCI with keyboards and mice. This original philosophy has been challenged and advanced in computer interaction (CI), both within the academic world and in the consumer market, with the introduction of body and voice controlled machinery. While the CI for humans becomes more diverse, so does the acknowledgment of computers for unintended animal users, who unscrupulously use the same machines. With the rise of body-governed machinery, could this methodology also be applied to these unintended users to enhance their lives? This chapter brings a briefly explored prologue into the inauguration of machines made by humans to be controlled intrinsically by a dog.

Animals have continually used technology, often being trained to used humanised systems through work processes. This use of ACI in working animals was continually exploited for human benefit until recently when a concept has emerged to use gained knowledge from HCI to empower ACI (Mancini, 2011). This is a simple notion that machines used by animals should be designed, in part, by animals and thus for animals, as discussed in the research philosophy (Chapter 3). Dogs have reputably been seen to watch screens, with this thesis seeking further in-depth ways of capturing this attention (Section 2.7.1). A system for dog-computer interaction (DCI) could gain significance through the analysis of what dogs pay attention too by enabling them to choose what to observe. For dogs motor driven interaction, following the Guidelines for dogs attention to screens and media (Section 3.2.2), the system would need to fit around the dogs ordinary behaviour. Thus, either head-based eye input or body movements and not the traditional button-based or trained for use machinery. By tracking an animal's behaviour, this allows systems to react to the dogs ordinary movements. It was with this reasoning that a baseline project was undertaken to build a head-tracking algorithm. This would recognise and react to a dog's head movement while watching a screen frame worked by previously explored HCI principles.

This software is built to allow the computer to recognise a dog's head direction and, from this, categorise the dogs head position. Whilst trackers have been used in animals before, such as in Williams et al. (2011) and Somppi et al. (2012), this is the first look at create a contact and training free tracker specifically for dogs attending to screens. Previously, animals have been tracked in ACI with systems for ball interaction (Pons et al., 2016) with cats and orangutans and dogs (Mealin et al., 2016) using Xbox Kinect. This system, however, requires intense initial foundational work to classify the shapes to form, first, a recognition of the animal and, second, the behaviour. This chapter questions if this recognition system could be developed away from the Xbox Kinect system and instead through video analysis as is done through this thesis by humans. This chapter presents a high-quality method of head tracking of dogs from a HCI standpoint. This research of building a tracking device aims to bring forward the possibility of animals having self-initiated interaction with screens whilst studying their behaviour and usability of these devices. The work reported in this chapter was published at *Nordic Conference on Human-Computer Interaction (NordiCHI)* (Hirskyj-Douglas et al., 2014) with the coding for image processing being done by Huailan, L.

6.2 Means to Track Visual Attention with Dogs

Most commercial eye-tracking systems, such as Tobii (2014), combine eye, gaze and head tracking. The three elements are used in a hierarchical way with the eye tracking being the tracking of the pupil and offering the most accuracy and the head tracking being of the model of the head in the world and offering the least accuracy. In a traditional eye-tracking system, the cameras fixate on the pupils, and when the pupil tracking is lost (maybe because the tracked individual makes a head movement), the system then seeks for the gaze (looking for eye-related aspects like edges of the eyes), and then, should that be difficult to find, fixates on the model of the head (Rommelse et al., 2008). In some cases, the accuracy of gaze tracking is all that is needed, in which cases the 'user' can be relatively less 'constrained' than where eye tracking is needed.

The constraints and the requirement for conformance are problematic for commercial eye-tracking and gaze-tracking systems when used with humans – they are even more problematic when used with animals. There is clearly a trade-off between accuracy and dog freedom (shown in Figure 32), which has to be considered when developing systems for tracking visual attention for dogs in ACI.

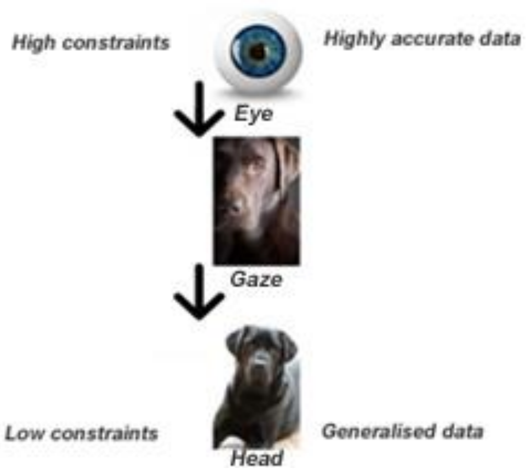


Figure 32: A continuum of eye-tracking, gaze-tracking and head-tracking technology in dogs from experimental conditions imposing high constraints on the dog's movements, producing accurate data, to experimental conditions imposing low constraints, producing generalised data.

There are many diverse means of object tracking that have allowed the concept to be used in many applications leading to the subject being an important topic in computer vision with large human face datasets being created for face tracking (Do et al., 2014). Object tracking has become commercially widespread with increasing low-resolution options thus a cheaper alternative to computer input. This tracking is habitually done with markers to define certain characteristics (in humans' eyes, nose and mouth), thus their position in relation to the observing object (camera). More recently, markerless tracking has been developed based on boundaries (Kulshreshth et al., 2013), but once again, like marker tracking, this is also based on skeleton tracking and the distance between shapes (colour boundaries).

Whilst there are several different methods to track eyes, the most commonly used nonintrusive eye tracking is pupil centre corneal reflection (PPCR). This method relies on reflections from the eyes with a camera showing these reflections (Tobbipro, 2016). The captured image is then used to identify the pupil and cornea of the eye, and from this, a vector is formed between the angle reflections. The vector of this reflection is combined with geometrical features to calculate gaze direction. Geometrical features are often danced image processing algorithms and physiological 3-D models of the face and the eye to help the program estimate the position of the eye within the space and the point of gaze (Tobbipro, 2016).

Dogs have vastly different and diverse characteristics than humans because of their skeletal structures, so previous well-documented face trackers, such as the low-resolution Xbox Kinect, would not identify their features. Pons et al. (2016) and Mealin et al. (2016) have managed to achieve Xbox Kinect tracking only through system modification. For a computer to recognise a dog's whole-body movements, a system would have to be developed to recognise the features of a dog and/or a dog's skeletal structure, that is, its joints' movements. Despite the abovementioned flaw, eye tracking has been done on dogs watching images as their eyes have the same light-reflecting properties as humans, the dog is trained to stay static (Somppi et al., 2012). This method of eye tracking though is only possible through static training. In practical use, therefore, this could overshadow the ordinary response possibly forcing the dog to gaze at the television.

In our work, the high-end faceLAB face tracker was used to try to track a dog's eye glare to get the eyes' saccades and gazes using Dog A (Figure 33). However, as mentioned above, even with markers placed on the face, the technology was unable to pick up the dog's features without training a static response.

Figure 33. faceLAB (Ekstem makina, 2016) being used with Dog A to test human trackers.

This lack of current technological solution is due to the diffraction of user requirements between humans and dogs. There is a need for a new low-cost solution with aa algorithm tailored for the dog rather than human features. This drive to recognise animals has been seen by both an increase in ACI research around recognition technologies (Pons et al., 2016; Mealien et al., 2016) and on consumer products to create AI for pets (Mlot, 2017).

Tracking the turn of the head (i.e., seeing where the dogs head is facing) can be considered a means of evaluating visual attention using the dog's whole-body movement. This is the method used within this study. Whilst this method loses accuracy as it is only a gross judgment of the location point of gaze, it is less limited by a specific setting and places no constraints on the dog following the guidelines given in Section 3.2.2. This method, as it is argued here, is suited reasonably well for measuring attention to large objects (it certainly won't work at a fine-grained level) and is thus a good choice for examining attention to screens in a dog-centred study design provided that the element of focus is sufficiently prominent on the screen.

6.3 Building MATLAB's Image Processing Algorithm

The implementation of recognition required the training of a machine to recognise the dog's features. This was done in a classic way by first gathering many images (a corpus), by determining features to classify and by training the recogniser to determine if the dog was looking centre, left or right. The system first recognised the dog within the image (sifting features) and then categorised the training images (created codebook) based on the built dataset. SIFT (sifting features) in MATLAB was used for feature extraction. The sifting features are the key points of an image that help the algorithm to identify the dog within the image. The codebook is a selection of dog images within the three head facing categorisations (left, centre and right).

To create a corpus of images, the researcher's dog (hereinafter referred to as Dog A) was filmed from the front to gather footage of the dog's head and face. The aim was to simulate the camera capture of an on top of screen set up as used within the study reported in the literature review (Section 2.7). The video was created by having the dog stand in front of the camera while the owner moved a dog treat in a circular motion thus enabling the capture of many different head poses taking from Williams et al. (2011) approach. This resulted in a 32 second video of Dog A's head movements.

The filmed dog head movements were then dissected into 736 frames to form a collection of still images. These images were sorted manually by the researcher into left, right and centre categories to allow the correct classification to be applied during the system training.

Figure 34. Images showing an example of the three classification criteria within MATLAB: left, right and centre.

Within MATLAB, image features based on colour difference were used for classification, a method in called 'Bag-of-Features'. Bag-of-Features creates a descriptor based upon the features noticed and clusters these set of given features into a set of 'bags' to be used to classify the image frame. For this image category classification method to be successful a majority of the image must have the dog within the frame, as shown in Figure 34.

The same images are used of Dog A as within the method are used here as the algorithm is built around this video, and the resulting dissected images. It was noted that the dataset had a larger proportion of right class (dog looking right) images, and as such, higher accuracy was expected in right head direction definition.

To build the codebook, images were selected within each classification using a random number generator. 63 were left class, 63 centre, and 87 right. For training the system, similar randomly selected images were used with 62 (left class), 62 (centre class) and 86 (right class). The higher selection of right videos randomly chosen, is reflective of the right classification bias within the data.

The code for this system (which was developed for the researcher by a third party – see acknowledgements) can be found in Appendix 3. The end result was a method that was not real time but that allowed a video to be split into image frames and then be investigated to identify the direction of attention of a dog's head.

6.4 Evaluation of the Algorithm

To test the system 630 frames were randomly selected using MATLABs random sample random number stream for classification, 210 apiece from left, centre and right. Table 10 shows the accuracy rates for the recognizer. The final system was able to identify images in training where the dog was watching with an accuracy of >82% with the best accuracy being for when the dog faced right. It is worth noting that there were more trained images facing right and this the system had more 'knowledge' of right facing images.

Class	Accuracy (%)	Images correctly identified
Left	89.0476	187
Centre	82.381	173
Right	94.2857	198

Table 10. Identifying images of the dog's face direction from video frames using the detection program made within MATLAB

These figures compare well with the current standard reachable human detection rate of 80% in face-tracking literature (Faux & Luthon, 2012).

6.5 Discussion

This study presented a contact- and training-free method of tracking the dog's attention to a screen, the accuracy rates are good but the effort involved in training the system are quite high. Initially, work could be done to strengthen the algorithm by increasing the corpus of images, thus also increasing the accuracy of identifiable images. As seen, this bigger corpus of right class images resulted in more images being correctly identified and could result in a higher detection rate for the created system.

One weakness within this study was that the images being identified were from just one dog – Dog A. However, the method presented could be iterated with dogs of varying features to allow the system to be trained and tested with a multitude of dogs and thus use cross-breeds of dogs. Another limitation in this method is that it is not real-time tracking, which could be done by employing markers and training the classification system on the marker movement. Whilst these markers could be put upon a dog, as seen with gait analysis, tracking here could potentially use infrared signatures from the dogs, as this is relatively similar across the breeds and is able to detect feature shapes regardless of colour variations (Figure 35).

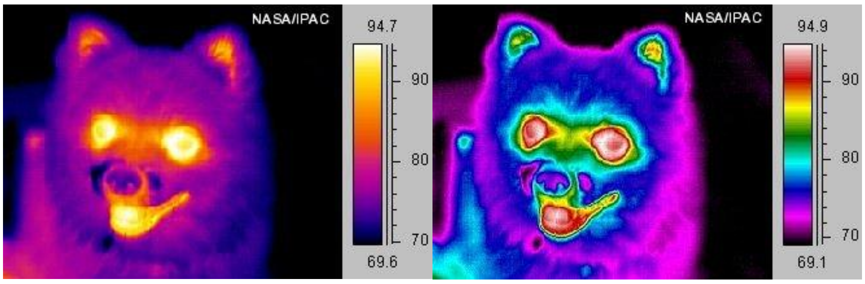


Figure 35. Image of a dog under an infrared camera showing features of the face. The two images show different colour variations which can be assigned to the infrared temperature markers.

This would also allow for different lighting conditions with, as shown in Figure 35, the ability of colour markers to varying temperatures to allow for multicolour heat signal tagging.

This method does, however, demonstrate that a dog's vision can be classified into three gaze postures (left, centre and right) using MATLAB. To take this method further, it could also be possible with directional classifications to generate a history map of where the dog is looking for a possible interactive product. Whilst this method does not analyse with such accuracy as those previously researched (Somppi et al., 2012; Williams et al., 2011; Guo et al., 2009), it does present a method of classification of the ordinary behaviour of a filmed dog. This method could be further improved by adding an adaptive background mixture model for real-time tracking, which subtracts the background calculating a reference image, subtracting each new image from the previous image and thresholding this result (Kawetrakulpon & Bowden, 2001). In this way, each pixel could be classified based on Gaussian distribution to bring the background mode (Stauffer & Grimson, 1999).

6.6 Conclusion

This research demonstrates the ability of MATLAB to create a working classification system for head direction for use with DCI technology, with possibilities of expanding this method to other animals and improving this system with dogs. Using the algorithm made, it is achievable to detect where Dog A's head is facing (left, centre and right) with more than an 82% accuracy rating. Whilst this investigation into a method of tracking a dog only uses a singular dog (Dog A), it does present a working method, with the future having an added ability to track dogs remotely and training-free. Suggestions here are made for future endeavours of dog tracking, to allow real-time and various setting-dependent classifications. This work sits within the narration of this thesis through continually exploring methods of classifying a dog's attention towards screen devices.

6.7 Contributions Derived from the Study

A suitable method has been used in MATLAB to classify where a dog's head is facing into three: centre, left and right, with an accuracy of above 82%. This provides evidence that this method of image classification can be used to dissect a dog's behaviour in screen systems.

Chapter 7

Study Two: Dogs' Interactions with Media: A Dog-Centred Approach to See the Interaction between Screens

7.1 Introduction

Following the investigation of methods to capture a dogs' attention towards a singular screen, building from the method of tracking dogs' head in the previous chapter (chapter 6), this chapter seeks to build a method to capture a dog's attention between multiple screens. This is in the aim of evaluating the usability of multiple screens for dogs through creating a method of assessment. This fits into the body of work within this thesis by building a method, along with initial findings, around a dog's preference, and following behaviour, over multiple screens. This method sits within the dog-friendly stance that this thesis has formed in a dog-centric manner (research philosophy [Chapter 3]).

Currently evaluations of these new animal-centric technologies have typically been conducted from the perspective of the human who has a vested interest in the technology solution—it being intended to provide a human advantage. Less studied is the experience of the animal, primarily because there are fewer effective methods to gather information from animals about their experiences with interactive devices and also because the design of technology for pleasure, or for the entertainment of animals, where the human is very much an observer, is still in its infancy.

One of the most used methods for evaluating the experience of animals in regard to interactive technology is to study what the animal is attending to in order to make a best guess regarding the animal's interest. This work has used head-mounted devices with peahens (Kjærsgaard et al., 2008), dogs (Williams et al., 2011), chimpanzees (Kano & Tomonaga, 2013) and rodents (Mueller et al., 2008) and, more recently, off-animal trackers with cameras positioned in front of animals including birds (Schwarz et al., 2013), primates (Tobii Eye Trackers, 2014), cats (Körding et al., 2001) and other vertebrates with laterally placed eyes (Tyrrell et al., 2014).

Positioning cameras and calibrating them to track gaze is problematic: animals move around in and out of range of the cameras, the cameras can be knocked out of position by energetic animals and the distraction effect of desktop or floor-set cameras is a confounds of any study. In previous work, we demonstrated that a dog's attention to large screens could be tracked by using cameras mounted behind the screen and by analysing the film from the camera. This low-intrusion method allowed the dog the freedom to wander around the experimental setup and limited confounds in the study. It was shown that this method could be used to determine if a dog was 'watching' TV.

Given that a dog's attention can be tracked in a non-intrusive way and that a dog can have freedom to choose what to attend to, three questions are raised: Do dogs choose what to watch? If they can choose, what do they prefer? How effective is a low-intrusion dog-friendly method for tracking animal attention?

These questions are considered in a study with two dogs (Dog A & Dog B), three screens and twelve videos. The study is especially timely given the relatively new interest in entertainment-style interfaces for dogs (and other pets) and is also timely as it moves away from constraining the dog to test for human-engineered responses towards letting the dog choose to participate in a research. The work reported in this chapter was published in the *International Journal of Human Computer Studies (IJHCS)* (Hirskyj-Douglas et al., 2016).

7.2 Dogs Interacting with Media

When considering an interactive system for a dog that would be more entertainment than work inspired, there is a need to understand what a dog would 'choose' to use and 'choose' to attend to. Early work in this area included Resner's 2001 paper on Rover@home, which presented systems that let humans at work interact with their pets at home. This is a key driver for the design of technology for dogs, as it is known that dogs left at home all day can be under-stimulated and under-exercised (Miklósi., 2014). To help address this issue, the creation of DogTV in 2012 anticipates the way for interactive TV content for dogs (DogTV, 2016).

The design of interactive media for dogs is a new area, and there is a keen interest to study this. The Kennel Club and Iams Co. found that almost 50 percent of the dogs they studied showed some interest in a TV screen (NBCS, 2013). There is not yet a view on how long, if at all, dogs should be 'watching' TV; it may be that, just as with game time, humans will eventually determine that TV time should be limited for dogs (Westerlaken & Gualeni, 2014). The possibility for the dog to decide in these matters is an enticing one. It is also not known through which senses dogs prefer to be stimulated, nor is there a full understanding of the effect of different aspects of media. There is evidence that music, for instance, can both calm dogs as well as agitate them depending on the genre (Kogan et al., 2012).

The design of interactive media for dogs should be considerate of their auditory and visual processing.

Where sound is used, the range of frequencies heard by dogs varies according to each species' bone structure and ear shape, but in general, when compared to humans, dogs have a greater sound sensitivity and can detect lower-intensity sounds (with dogs having a sensitivity range between 67 and 45,000 Hz approximately compared to 64 and 23,000 Hz for humans) (Strain, 2016). In DCI research with televised media, it was shown that often a sound, as well as a fast movement on a screen, could attract a dog to the media (Section 2.7.1). This study acknowledged that both sound and vision can be attractors to the screen. When describing a dog's vision, there is much to consider. Ford (2014) describes vision as a result of several aspects: (a) the ability to perceive light and motion, (b) visual perspective, (c) field of view, (d) depth perception, (e) visual acuity and (f) colour vision. In terms of light, a dog's vision is highly sensitive to light: their reflector tapetum helps them see in darker light than humans for example (Miller & Murphy, 1995). It is also suspected that this reflective tapetum, coupled with the dogs' large peripheral visual field, allows for greater detection of motion than humans (Ford, 2014). That said, the ability of dogs to discriminate between different brightnesses is thought to be relatively poor, as shown in the example in Figure 36 (Prettere et al., 2004).

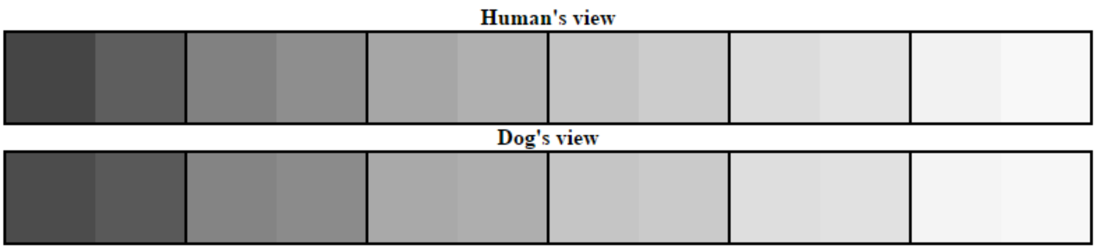


Figure 36. Rectangles with different brightnesses as shown through a human's and dog's perceived view (Peter, 2013)

A dog's visual perspective, is influenced by several species and breed-related differences. The height of the eyes, the location of the eyes and the head bone structure have an effect. The average dog has 240 degrees of vision (humans have 180 degrees) (Ford, 2014), which allows for enhanced stereopsis (binocular depth perception) with a 30- to 60-degree overlap (Miller & Murphy, 1995). Whilst dogs have colour vision, they have fewer colour-sensitive cones (photoreceptors) than humans and are commonly described as being 'red-green colour blind'. Figure 37 shows how colours are differently 'seen' by dogs and humans.

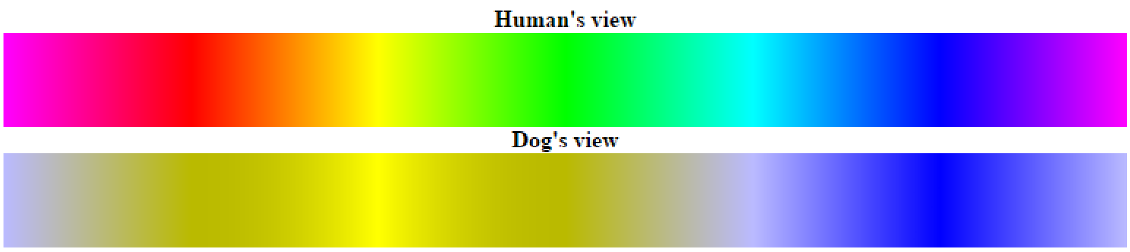


Figure 37. A full RGB spectrum showing how the same colour line would be perceived by a dog (Peter, 2013)

In terms of colour perception, the neutral point for a dog is towards the blue end of the spectrum (480 nm) (Miller & Lights, 2001). The visual acuity of a dog is somewhere around 20/75 (meaning that at 20 feet, a dog can distinguish objects a human would from 75 feet), but this varies according to the placement of the eyes (Ford, 2014).

7.2.2 Making Sense of Interactions

Given that a dog can be seen to be responding to media, either through reactions to sound or movement or through reactions to images in the media, the challenge for the designer of interactive technology for dogs is to interpret those reactions and the behaviours associated with media in order to use these to inform design.

Eye, gaze and head tracking systems have two main purposes in human-computer interaction (HCI); they allow an observer to gather data to see where a human is looking, and they allow the design of 'gaze-based' interaction by making use of dwell time as an input mode (Nagamatsu, 2010). The most noted growing area of eye tracking is within HCI interfaces operated by eye movement gestures (Rozado et al., 2012; Wobbrock et al., 2008).

The ACI field has used tracking technologies to study how dogs attend to screen technology, the foremost being the pioneering work with pet dogs by Somppi et al. (2012). In this work, in which the dogs were trained to use a headrest to overcome the eye-tracking problem of staying still for light reflections and/or focus, it was found that dogs attended to dogs' faces more than humans' faces. Somppi et al.'s experimental arrangement was in contrast to the design by Williams et al. (2011), which held the tracking technology on a muzzle on the dog; this system did not constrain the dog's head position but potentially would affect the head movement of the dog.

Other relevant works on how and to what a dog attends to include the study by Guo et al. (2009), who demonstrated that dogs typically present the left side bias whilst face-watching that humans, apes and other primates possess. It has been speculated that this is due to dogs co-habiting with humans, with the consequence that this habitat has influenced their behaviour. Racca et al. (2010) explored dogs' abilities to discriminate between different dogs and humans based on facial cues and found that dogs can use facial cues to distinguish individual dogs and humans.

7.2.3 Interpreting What Is Seen

Dogs' behaviour is an important indicator of their reactions to stimuli and therefore central towards understanding dogs' interactions with systems. Whilst dogs share our homes and are often referred to as 'artificial animals' due to this domestication (Serpell, 1995), they cannot share their desires and wants easily with humans (the two species having only a limited shared language) (Miklósi, 2014). Because of this, humans are forced to interpret much of dogs' behaviour in order for them to infer meaning from dogs' actions. Complicating this is the interplay between dog and human where one affects the behaviour of the other, both at the individual level (dog and owner) and at the species level (dog as a domesticated animal) (Lichtenstein, 1950; Solomon & Wynee, 1953). The relationship a dog has with machinery and humans is often questioned, that is, whether a dog's social cognitive ability derives from domestication or whether this is formed individually as a result of socialisation during the dog's upbringing (Abdai et al., 2015). Even given that dogs have lived with humans for many millennia, and even where a dog has lived with an individual owner for some time, there is no certain way to interpret dog behaviour. Given a wide range of social behaviours, and many different personalities, interpreting behavioural observations can be tricky (Miklósi, 2014; Väätäjä, 2014).

In terms of knowing what a dog is doing when it attends to a TV screen, there is always going to be a problem of interpretation. It can only be inferred that the dog is mentally attending to the screen when glancing at it, and there has to be some correlate of time spent in attention to assume any cognitive engagement (Mui et al., 2008). Attention, and what it means, can be complicated by the presence of a human in the situation as the human, for example, glancing at a screen, might influence why, and in what way, a dog would glance at a screen (Horn et al., 2013). In our own work, we chose to determine that attention was ‘longer’ than just a glance, and we also aimed, in the study design, to minimise the effect of the ‘human in the room’.

7.2.4 Enjoying the Interaction and the Research

Arguably a dog can be engaged with a system without enjoying the interaction. This has been reported in studies with humans where they will watch videos that disgust them (Kunz et al., 2009). Enjoyment is a hard thing to quantify and so far, has only been studied through the measurement of cortisol levels and heart rate levels (Rehn & Keeling, 2011; Geurtsen et al., 2015) and owner assessments (Zamansky et al., 2015). Engagement and enjoyment, however, are integral to a playful system experience, but whilst the measurement of these is beyond the scope of this thesis, a core principle in DCI is to ensure the dog is not coerced or tricked into doing the research work.

In 2011, in the Manifesto for Animal-Computer Interaction, Mancini (2011) wrote of several needs for this emerging field and in particular wrote of the need to respect each species, to only work with a species if it advanced research for the betterment of that species’ existence, to carry out the research in the animal’s habitual context and to allow the possibility for the animal (i.e. dog) to withdraw and give consent. As discusser added to these principles to the effect that ideally the research would be done in the dogs home, in a safe place and that there would be no training (Section 3.2.2). These principles taken together specify a new way to look at research design where the dog is comfortable, is free to participate or not, is not trained and does work for the benefit of its species. In selecting research content and research situations, there is additionally a need, as reported by Väätäjä (2014), to assess and safeguard the welfare of the dog.

7.3 Study

Against a backdrop of entertainment solutions for dogs, there is a need to better understand dog attention towards screens and within a philosophical constraint of working with dogs in a dog-centric dog-kind way; the study described here aimed to determine if a non-intrusive, dog-friendly method could be employed to answer the following questions: can a dog choose what to watch, and given a variable content, is there a preference for some content over another? There were two main aims: one was to answer the scientific questions and the other was to explore the extent to which a dog-centred method could be used in this endeavour.

The dog-centric research design naturally emerged from the concerns expressed by the ACI community, especially from Mancini (2011) and Väätäjä & Pesonen (2013). Before undertaking the research, ethical clearance was given by the researchers' institution. In addition, the research aimed to comply with the ethical principles from Mancini (2012) and our own (Principles for Dogs Attending to Screens and Media), specifically seeking to (a) allow the dog to consent and withdraw, (b) conduct the research in a dog-friendly/homelike space, (c) design research that needed no training or coercion, (d) use research tools and instruments that would cause no harm and (e) respect the species in providing species-appropriate tools and instruments. The method described here aims to be dog friendly at drawing out what a dog watched in an interactive product. The method highlights the tension between undertaking a dog-kind study vs. a research-kind study: the balance between being compassionate to the dog and gathering data. This tension is highlighted in Session 3 within this work, where, in one instance, due to the methodological design choice of allowing the dog to walk away, almost no data was collected and that which was collected was too scant to be useful.

7.3.1 Method

The scientific intention in this work was to determine what, if anything, a dog might watch given a choice of content and to additionally draw insights on whether a dog was making a choice in a particular way. The work was based on the use of video clips played in competition (i.e. simultaneously) with one another on three screens and on these clips rotating across the screens. Twelve video clips were played in sets of three at a time (each set of three being a single session), and when played in a set of three, they were switched from one screen to the next until each had been played twice on each screen (six sets). Eight of the videos featured dogs (A, D, E, F, G, H, I, J), two featured humans (C, L) and two featured other animals (B, K). The videos are described in detail in Section 3.1.3 below. Two dogs each did the four sessions, each doing the sessions over two days. This resulted in an experimental setup of four sessions (two sessions each day over two days). This was repeated twice: once for Dog A and once for Dog B.

Day 1
Session 1: Videos – Dog Video A, Dog Video B and Dog Video C
Session 2: Videos – Dog Video G, Human Video H and Animal Video I
Day 2
Session 3: Videos – Dog Video J, Human Video K and Animal Video L
Session 4: Videos – Dog Video D, Dog Video E and Dog Video F

The videos were actively switched between the three screens both to explore if the dog could follow a video and to eliminate screen position bias. Each video was set up to play for 20 seconds on its chosen screen, and then a blank screen was presented for 30 seconds before the video continued to be played on a different screen. The blank screen gave the dog a break between the media so not to overwhelm the animal as done and suggested in other ACI studies (Zamansky et al., 2015; Westerlaken & Gualeni, 2014).

7.3.1.1 Study Venue

Ideally the study would have been conducted in the homes of the dogs, as advocated in our earlier research. However, there was a tension in being able to set up a controlled study, with identical screen positions and with a similarly constrained interaction space, for two dogs over several days, and so for that reason, the sessions were each conducted in the same small room in the university of the researchers. The room had no distractions; there were the three screens (see below), and there was a corner for the dog to have his things—essentially a drink, some toys and a place to lie down. This gave a homelike feel to the experimental setup. The participating dogs could walk away from the study area at any time; they could take a drink, play with toys or explore the room rather than watch the screens. Playful interaction allowed the dogs to have a self-initiated play (Pons et al., 2015). To minimise human influence on the dog, no training was done, and no rewards were given. Whilst it was clearly impossible to completely remove the human from the situation, the aim was to keep the interaction playful using the principles of dog-centric DCI, as laid out within this thesis research philosophy (chapter 3).

Three identical LCD 21.5" monitors (W2243T) were placed in a row at one end of the room (Figure 38). This presented the dog (C) with a choice of what content to view. Video cameras (Logitech Pro 9000 webcams) were positioned above each of the screens (giving face-on recording), and an additional over-viewing video recorder (Sony HDD Video Camera SR10E 40GB [A]) was placed centrally to capture the room. Behind the screens, hidden from the dog's view, were three laptop computers (Lenovo ThinkPad Laptops TP00060A [B]) that allowed the chosen media to be presented to the dog from a previously programmed selection. The screens were positioned at the dog's eye level approximately 50 cm from the ground. This allowed the dog's gaze to be at the height of the screen. The media presented to the dog included visual and auditory stimulation.

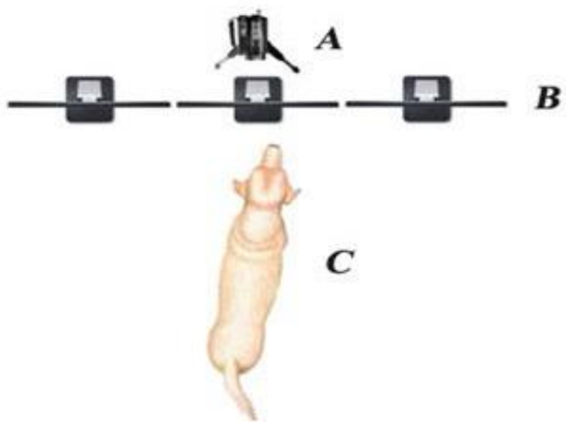


Figure 38. The basic study setup including apparatuses for communication: (A) the main camera, (B) the laptops and webcams and (C) the dog subject

As dogs' vision has fewer differentiations in brightness than human vision, the screens had to be illuminated, which is why LCD screens were used (Wang & Nikolic, 2011). The sound was played through the laptops' speakers; these were positioned directly behind the three screens and had very good noise quality and a good dynamic range. Although the laptops' sound was turned on to allow the dog to experience the full video interaction, it must be noted that as three videos were being played at once, this could have resulted in the media being over-stimulating both visually and acoustically. For this reason, the volume on the video was not loud, especially given the dogs' hearing capabilities. Overall, the system was therefore both visually and acoustically suited for dogs.

7.3.1.2 Participants

The participants in this study were Dog A and Dog B as described in study one (Chapter 6). At the time of the study Dog A was 39 months old and Dog B was 11 months old. Neither of the dogs had visual problems as tested using Ford's (2014) crude method of following objects at varying distances and each had a full health check from veterinarians. The two dogs were selected as they were known by, and familiar to, the researcher. This clearly limited the scope of the study in terms of having multiple dogs participate, but it ensured that the dogs were comfortable whilst participating and ensured that the researcher was safe with the dogs given that the study was in a closed room with only one human present.

Figure 39. The dogs used within the study. Left and centre show Dog A, and the right image shows Dog B.

7.3.1.3 Video Selection

The 12 videos chosen were of three genres: dog, animal and human (described in Table 12). These were chosen as previous research in the literature suggested that dogs would already have a preference with this mix: that being for dogs, then other animals then humans (previous work (Section 2.7.1); Somppi et al., 2012). The experiment aimed to test this and also test whether the dog would follow that preference across screens.

The eight videos of dogs (A, B, C, D, E, F, G and J) were all DogTV videos downloaded from YouTube (YouTube DogTV, 2015) and edited to show the first two minutes of the video. The two animal videos (I and L) were also DogTV videos from YouTube. The human videos used (H and K) were *Coronation Street* clips from YouTube as they contained talking without a commentator (YouTube *Coronation Street*, 2015). When selecting the videos, only realistic videos were chosen with no animated, cartooned or puppeteered images. This reduced the confounding variables within the study.

To describe the visual content of the video, the frames of each video were analysed against the vector scope (YUV), Parade RGB, Waveform Luma and Histogram. For this analysis, a single representative frame was taken from each video. This was considered acceptable, as the videos, being short in length, did not contain significantly changing imagery. Adobe Premiere Pro CC was used to analyse the frames, with an example output shown in Figure 40.

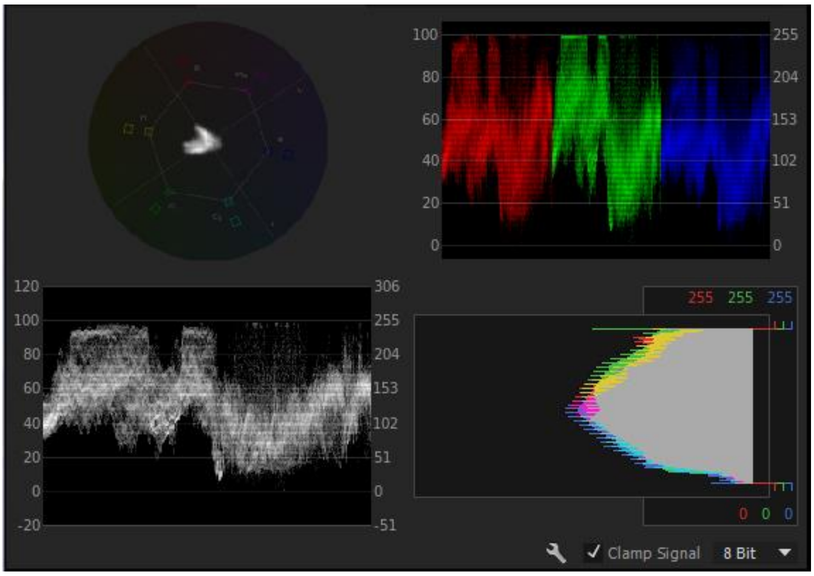


Figure 40. An example of the output of Adobe Premiere Pro CC frame analysis of the videos used within the study. Top right shows the vector scope (YUV) on a colour wheel, top right is a parade RGB, bottom left is the waveform luma and bottom right is a colour histogram.

The vector scope (YUV) displays the video's chrominance information (saturation) on a blue, cyan, green, yellow and red pattern. Videos E and J had a high saturation, with often a high scope towards the red spectrum. Videos G and B had the lowest saturation, making them the darkest of the videos. The high red spectrum in these videos meant that the details were possibly less likely to be picked out by dogs due to dogs having some red-green colour blindness. Videos K, D, C and A all had scopes leaning towards the blue spectrum, making them slightly more suitable for dogs.

Parade RGB displays waveforms of the level of RGB within the video clip. Within the majority of videos, the colour was evenly distributed with only G, C and D having a poor distribution of colour. The colours of video D in particular had a very limited range, and video G had very little variance. This is less important in terms of dog viewing than the absence/presence of red colouring but could have had an effect if pronounced.

Waveform luma displayed the luminance information. Most of the videos had equal waveforms, suggesting a vaguely equal ratio of luminance. Video D only had waveforms towards the middle, and video K had waved patterns throughout. Videos K and A in particular were very bright shown by their waveforms going repeatedly to the very edge. Video G had a relatively underexposed waveform, meaning that the video was relatively dark. With dogs less able to distinguish changes in brightness than humans can, there is more of a need for contrast; thus, unlike for humans, videos K and A were highly suitable for dogs.

The histogram represents an overall distribution of colours within the image frame. Videos C, J and F had the most contrasting colours, with red/pink colours taking dominance over other colour highlights. Ideally the videos would have had a bluer centred variance, such as video F which had more blue distributed throughout. Overall, whilst the videos presented slight variance of visual presentation, none of the videos were on the extremities of any colour scale.

In terms of colour suitable for dogs, videos K and A initially appeared the most suitable for dogs due to their colour being towards the blue spectrum and due to their high brightness contrast, giving more disparity between colours. Table 11 shows further details about the 12 videos, noting aspects of imagery and audio as well as details about the interactivity in each one.

		Dog			
	Video	**A**	**B**	**C**	**D**
	Contents	**Two Dogs Growling**	**Dog Balloon**	**Dog Surf**	**DogTV**
Audio	Number of Voices	2	4	1	0
	Music Overlay	None	None	None	Yes
	Voices Off Screen	None	Yes (Laughter/Talk)	None	None
	Ambient Sound	Camera Zoom	None	None	None
Video	Background	Static	Static	Dynamic	Constantly Changing
	Moving Camera	Zooming In/Out	Zooming In/Out	Following Entity	POV (5%) Following Entity (95%)
	Camera Angle	Medium Shot	Wide Shot	Medium Shot (10%) Wide Shot (90%)	Medium (60%), Wide (30%) Panning (10%)
	Context/Place	Home	Outside Garden	Beach	Outside Garden Beach Field
Content	Number of Entities	2	3 (1=10%)	12 (10 people 5%)	37 (Constantly Changing)
	Emotive State	Playful	Playful	Relaxed	Playful

		Dog			
	Video	**E**	**F**	**G**	**J**
	Contents	**Dogs Relaxing**	**Dog Field**		**Dogs Playing in Field**
Audio	Number of Voices	0	0	0	1
	Music Overlay	Yes	Yes	Yes	Yes
	Voices off screen	None	None	Baby Laughter	Person Praising A Dog/ Laughter
	Ambient Sound	Dog Sound	None	Waves/Magic Wand/Panting	Knocking/Bells/Kisses
Video	Background	Static	Static	Static	Static
	Moving Camera	Panning, Following Entity (90%)	POV Following (50/50%)	Panning	Following (2nd Person)
	Camera Angle	Medium (60%) Wide (40%)	Medium	Medium	Medium/Wide (10%)
	Context/Place	Outside Field	Outside Field	Beach (90%) Field (10%)	Outside Field
Content	Number of Entities	3 (50%/25%/25%)	1	3	2
	Emotive State	Relaxed	Playful	Relaxed/Sad	Happy Playful

		Animal		Human	
	Video	I	L	H	K
	Contents	Zebra	Squirrel	Corry	Corry
Audio	Number of Voices	0	0	5	4
	Music Overlay	Yes	None	Yes (5%)	Yes (5%)
	Voices Off Screen	None	None	None	None
	Ambient Sound	Bird Sounds	Bird Chirps/ Car Engines	Car Engine	Car Engine
Video	Background	Dynamic	Static	Dynamic	Dynamic
	Moving Camera	Following (90%) Second Person	Second Person	Second Person	Second Person
	Camera Angle	Wide (60%)/ Medium/Close (10%)	Medium	Medium/Wide (10%)	Medium/Wide (10%)
	Context/Place	Savanah	Garden	Street	House
Content	Number of Entities	20 (5%)	1	6	4 (50% all)
	Emotive State	Relaxed (Playful 10%)	Playful	Sad	Angry

Table 11. Summary of the audio, video and content of the videos used within the study. Where the number was not static, a % is given to the amount of time present within the media.

In the analysis shown in Table 11, the camera angle is described as 'medium' when the subject and background were taking up a roughly equal portion of the image, 'wide' when the main subject had less than 50% and 'panning' when the angle was continually panning over and/or around the subject. The background was termed 'static' when it did not move and 'dynamic' where there was a lot of movements. In most of the videos, audio content was simply music overlay with no voices being present other than ambient sounds. Only videos G, J and B had off-screen voices. Almost all the videos showed outside views, often in rural settings. On average, the number of main objects and characters within the video was eight, and most of the videos were described as relaxing or playful.

7.3.1.3 Procedure

In each study, the dog came into the room only when all the apparatuses were ready for use. The videos were sliced into 20-second clips and then distributed across the screens, as shown in Table 12, which shows how this worked for Session 1. For the other sessions, the only variation was in the videos used. The recording equipment played all the time the dog was in the room, and so periods when the dog walked away or when attending to the content were all captured. The dog was free to move around the room as he chose.

Screen 1	A	30	B	30	C	30	B	30	A	30	C
Screen 2	B	Seconds	C	Seconds	A	Seconds	A	Seconds	C	Seconds	B
Screen 3	C	Break	A	Break	B	Break	C	Break	B	Break	A

Table 12. How the video played on each screen showing the rotation of content and the timings

During the study, the researcher watched the dogs in a cautious way, ensuring not to watch the media to avoid influencing the gaze results (Hare & Tomasello, 1999). The researcher did not ignore the dogs completely as this would have been inappropriate but did try as much as possible to be ‘invisible’ in the room.

7.3.2 Analysis

The recorded data were analysed by video editing the four videos together (as shown in Figure 41) and then timing each interaction using a stopwatch. There were very few instances where it was not clear where the dog was attending to, and it was easy to tell when the dog was looking at the screen. The dog was counted as attending to the video when seen, verified by four cameras and the researcher, to be watching (face and eyes facing) one of the three videos. The dog was classed as ‘not engaged’ when he was not watching (face and eyes facing) any screen.

Figure 41. Camera images edited together to give a full video of the study. This is a screenshot taken from Video 1 of Session 1, Dog A. The top image shows the overall shot whilst the bottom three images give the perspective from the three cameras on top of each media (right, centre and left).

The data were scrutinised within the six data sets in each session (Session 1, Set 1 for example) based on the screen’s orientation (left, centre, right) and the content of the video showing on that screen. Table 13 shows the first four sets for Session 1 Dog A. In this study, the three videos all contained single or multiple numbers of dogs—A, B and C, as described in Table 11.

	Set 1	Set 2	Set 3	Set 4
Screen 1 (right)	A – 2.6 s, 13%	B – 0 s, 0 %	C – 2.4 s, 12%	B – 5.4 s, 27%
Screen 2 (centre)	B – 1.7 s, 9%	C – 3.2 s, 16%	A – 9.7 s, 48%	A – 0 s, 0%
Screen 3 (left)	C – 3.2 s, 15%	A – 0 s, 0%	B – 5.7 s, 29%	C – 2.4 s, 12%
Screens total	7.5 s	3.2 s	17.8 s	7.8 s
No Screen	12.6 s, 63%	16.8 s, 84%	2.3 s, 11%	12.2 s, 61%

Table 13. Session 1: Raw data set showing Dog A's attention or absence of attention with three screens along with this raw data set then turned into percentages. The full set of raw data can be found in Appendix 4.

As well as recording total time spent in attention to each video per set, a conversational style analysis was also carried out where the movement of the dog's attention from one screen to another was tracked. This is shown in Table 13 for Dog A for Session 1 for the first and third sets. The third row in this table shows the video that was being shown in each case; the second row shows the location of the video. This analysis was done for all the sessions within the experimental work.

Table 14 shows how in Set 3, Session 1, Dog A looked around quite a lot but spent most of his attention on video A, returning to it four times after the initial look at it and then spending a considerably long time focusing on it at the end of the period (5 seconds). It also shows two spans from R to L and L to R without looking in between at C and shows how most of the changes in attention were between adjacent screens.

	Set 1					Set 3									
Screen	L	C	R	L		C	L	R	C	R	C	R	C	L	C
Video	C	B	A	C		A	B	C	A	C	A	C	A	B	A
Time (s)	1.2	1.7	2.6	2		1.2	4.1	0.8	0.7	1	1.2	0.6	1.5	1.5	5

Table 14. Session 1: This table shows the dog's attention to each of the different screens: R (right), C (centre) and L (left), and the different videos (A, B and C).

7.3.3. Results

The raw data from this study can be explored in Appendix 4. The results are presented in three sections. The first section considers the overall data gathered, and then the subsequent sections consider where the dogs looked and what the dogs followed.

A video event is a showing of a video across the three screens. For a dog to engage with a video event, it had to be shown to be looking at least one of the videos during that period. Dog A engaged with a total of 16 (out of a possible 24) video events (4/6 in Session 1 [the first four—as shown in detail in Table 13 and summarised in Table 17], 5/6 in Session 2, 2/6 in Session 3 and 5/6 in Session 4), with a total engaged time of 212.2 seconds (36.2 seconds in Session 1, 68.6 seconds in Session 2, 23.5 seconds in Session 3 and 84.5 seconds in Session 4). Dog B engaged with a total of 17 (out of a possible 24) video events (4/6 in Session 1, 4/6 in Session 2, 6/6 in Session 3 and 3/6 in Session 4), with a total engaged time of 96 seconds (35.9 seconds in Session 1, 23.7 seconds in Session 2, 15.3 seconds in Session 3 and 20.8 seconds in Session 4).

Describing 'dog watching time' as time when the dog attended to at least one video in the video event, Dog A could have been watching for a maximum of 320 seconds (16 × 20) but actually watched for 212, Dog B could have been watching for 340 seconds (17 × 20) but watched 96. This shows that Dog A watched around twice as much content as Dog B.

7.3.3.1 Looking, Glancing and Seeing

The longest time a dog looked in one place was afforded to Dog A who looked for 18.1 seconds at video F (a dog in a field) that was playing on the middle screen. It was noted that the attention times got longer near the end of each 20-second interaction segment. The four greatest viewing times for Dog A were 8.3 seconds (Session 4, Set 4), 8.5 seconds (Session 4, Set 2), 10.4 seconds (Session 2, Set 5) and 18.1 (Session 4, Set 5). Dog B (a younger dog) had reduced viewing times, with his four highest times being 10.08 seconds (Session 4, Set 2), 6.56 seconds (Session 1, Set 2), 5.3 seconds (Session 1, Set 2) and 4.4 seconds (Session 2, Set 4). Both dogs settled for more than eight seconds on Session 4, Set 2 on the same video: A, which was a dog video.

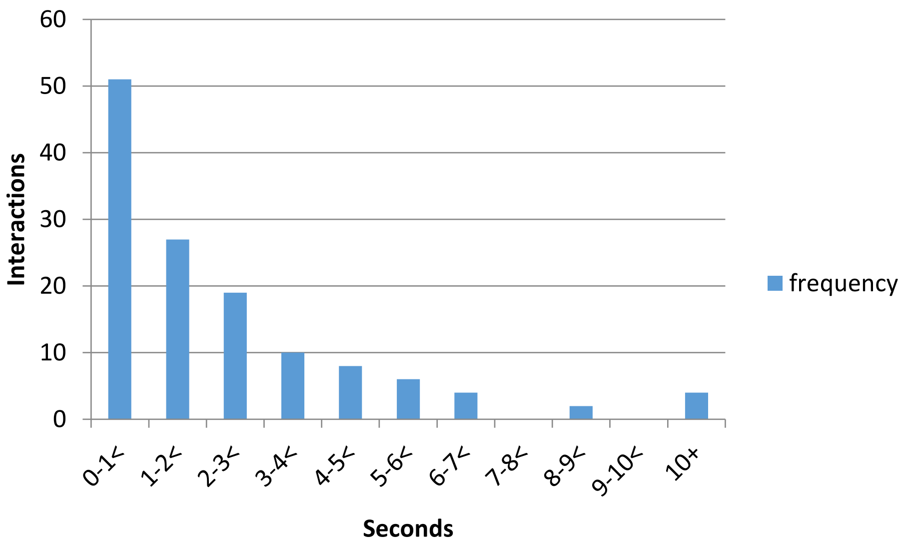


Figure 42. Frequency distribution table of periods of attention that the dogs (A and B) had with the three screens

It could be hypothesised that this settling behaviour is a result of the dog switching through content before settling on one option. However, as the videos changed after 20 seconds, new glances would then have to be established in order to 'map out' the surroundings, in other words, discover what was on the adjacent videos, once again affecting normal viewing habits. Figure 42 shows the overall viewing times for both subjects and shows a clear fluctuating downward distribution, indicating that most the periods of attention to the screen were mere glances. This graph shows both dogs had many small periods of attention with very few longer spells. This could be due to the limited timescale resulting in the dog not settling into watching but glancing continually instead.

Dog B had considerably lower mean periods of attention (1.49 seconds), below half that of Dog A (3.06 seconds). It has been speculated that due to his younger age, this dog was not as interested with the media and could not hold attention as long, as shown by these shorter attention episodes. Unlike Dog A who would physically as well as visually settle and watch media, Dog B would pace, frequently approach the human, roll on his back and use other gestures to indicate that he wanted to play (Miklósi, 2014). This work here opens up questions as to the role that age plays among dogs' viewing habits, thus times, of watching media.

7.3.3.2 Where the Dog Looked

The data were scrutinised for preferences in terms of screen position to see if the dogs preferred one position over another. Tables 15 and 16 show the total time spent by each dog looking at each screen as well as the average time spent per screen averaged over the number of video events (16 for Dog A and 17 for Dog B). These tables show that for Dog A, the centre screen was favoured but that there is no preference for Dog B.

Dog A (16 Events)	Session 1	Session 2	Session 3	Session 4	Total	Mean Per Event
Right	10.36	11.95	5.5	17.19	45.00	2.81
Centre	14.54	34.04	12.28	51.07	111.93	6.99
Left	11.27	12.22	5.72	16.25	45.46	2.84

Table 15. Total time spent by Dog A looking at each screen and averages for each screen based on the number of video events attended to (16 in this case)

Dog B (17 Events)	Session 1	Session 2	Session 3	Session 4	Total	Mean Per Event
Right	2.65	1.22	3.55	16.30	23.72	1.40
Centre	6.52	8.37	2.39	3.93	21.21	1.25
Left	26.77	14.13	9.4	0.60	50.90	2.99

Table 16. Total time spent by Dog B looking at each screen and averages for each screen based on the number of video events attended to (17 in this case)

Given that each video event was of 20-seconds duration, it can also be noted from these two tables that the dogs spent a lot of time not attending to any of the three screens as in each of the sessions there was a maximum of 120 seconds of viewing time available to each dog.

7.3.3.3 What the Dog Looked At

Table 16 shows the total time as well as the average time per dog per video when accounting for the number of video events that the dog was attending to the screen whilst each video was being played. Thus, in the entry for Dog A for video A, in Session 1, the table shows that Dog A only attended to the screen for four of the six possible video events—having gone to lie down for the last two events, and so the average of 3.08 seconds per video event is obtained by dividing the total of 12.3 seconds by 4 rather than 6. As has been highlighted elsewhere in this chapter, Dog A was around twice as attentive to the video material as Dog B, and so this table also presents, in the last column, a normalised set of average viewing times so that a comparison can be made across the videos and between the two dogs.

Video	Dog A Total (N)	Dog A Average	Dog B Total (N)	Dog B Average	Dog A Average Normalised	Average Across Dogs	Ranked Position
A	12.3 (4)	3.08	19.3 (4)	4.83	1.46	3.14	2
B	12.8 (4)	3.20	3.7 (4)	0.93	1.52	1.23	11
C	11.1 (4)	2.78	13 (4)	3.25	1.32	2.29	3
D	34.8 (5)	6.96	15.8 (3)	5.27	3.31	4.29	1
E	24.8 (5)	4.96	1.4 (3)	0.47	2.36	1.42	9
F	24.9 (5)	4.98	3.7 (3)	1.23	2.37	1.8	6
G	17.1 (5)	3.42	11.4 (4)	2.85	1.63	2.24	4
H	28.8 (5)	5.76	3.2 (4)	0.8	2.74	1.77	7
I	22.7 (5)	4.54	9.1 (6)	2.28	2.16	2.22	5
J	11.2 (2)	5.60	2.9 (6)	0.48	2.66	1.57	8
K	9.4 (2)	4.70	3.5 (6)	0.58	2.23	1.41	10
L	2.9 (2)	1.45	9 (6)	1.50	0.69	1.10	12
Total	213		96				
Mean		4.29		2.04	2.04		

Table 17. Time spent in seconds by each dog looking at each video. Columns 3 and 5 show the average time spent looking at each video per 20 seconds of video time engaged in (per video event). Column 6 shows the data for Dog A adjusted to the data for Dog B in order to better understand any preferences. In columns 2 and 4, *N* represents the number of video events (out of a maximum of six) that the dogs engaged in.

From Table 17, it appears that videos D, A, C, G, I, F and H were all the more watched videos. However, this analysis fails to take account of the 'competing' videos that were being played and also fails to take account of longer spells of attention, by the dogs on single videos—which may be a sign of preference. Dog A seemed to attend most to videos D, H and J whilst Dog B seemed to attend most to videos D, A and C.

To further investigate which, if any, of the videos the dogs preferred, a decision was made to describe a 'favourite' video as being one that was watched at least twice as much in a single session, as the least viewed video. This definition allowed the researchers to distil out videos that were seemingly preferred as opposed to simply picking up the video with the longest duration of viewing. This process is explained in the following example from Dog A, Session 2.

	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	TOTAL
Dog (G)	2.43	0	5.44	4.83	3.98	0.46	17.14
Human (H)	6.91	0	3.99	0	4.26	13.58	28.74
Animal (I)	2.84	0	2.3	0.66	3.27	3.28	12.35
no screen	7.82	20	8.27	14.51	8.49	2.68	61.77

Table 18. Detail from the videos watched by Dog A in Session 2, showing the specifics from each set and demonstrating how 'favourite' videos were described

Each set was scrutinised to see if one video was watched (where we use this in the loosest sense of the word as a synonym for 'attended to') for at least twice as long as the least favoured video in the sets (video events). These are shown in bold in Table 18. In this case, there are two instances: the video of the human (H) and two of the videos of the dog (G) in Sets 1, 6 and 3, 4 respectively. This is described as each of these videos both (and therefore jointly) being the favoured video and is represented in row 4 of Table 19 below. By duration, video H was clearly watched the longest (as shown in row 3 of Table 19 below). When no-screen watching is factored in as a choice that a dog might make along with the choice to watch a video, then in terms of the definition of a favoured event having to be 'watched' twice as long as the least watched event, then the no-screen effectively becomes the favoured event, and it had the longest duration (see row 2 in Table 19 below).

Dog A	Session 1	Session 2	Session 3	Session 4
Favoured by duration including the no-screen option	nothing	nothing		D (Dog) E (Dog)
Favoured by duration not including the no-screen option	C (Dog)	H (Human)		D (Dog) E (Dog)
Favoured by turns	C (Dog)	H (Human) G (Dog)	K (Human) L (Animal)	D (Dog)

Table 19. Dog A's favourite video with analysis based on the algorithm of twice watched over least watched for (a) duration and (b) turns

Dog B	Session 1	Session 2	Session 3	Session 4
Favoured by duration including the no-screen option	nothing	nothing	nothing	nothing
Favoured by duration not including the no-screen option	A (Dog) B (Dog)	H (Human)	L (Animal)	E (Dog)
Favoured by turns	B (Dog)	H (Human)	J (Dog) L (Animal)	D (Dog)

Table 20. Dog B's favourite video with analysis based on the algorithm of twice watched over least watched for (a) duration and (b) turns

The most interesting finding from this analysis is that for all but one session (Session 4, Dog A), the most favoured option was to watch nothing. This suggests that the general watching of these videos in this context was not especially engaging. Table 19 shows that Dog A had a clear favourite video in Session 1, which was video C, of a dog surfing. It seems that this dog also favoured video H as well as videos G, D, E, K and I. Dog B clearly favoured video H (Table 20), as well as A, B, L, G, D and E, but interestingly did not have C as a favoured video even though this was preferred by Dog A.

Video H was both looked at for a long time, and turned to multiple times, by both dogs. This showed humans in *Coronation Street* hugging and saying goodbye to each other. This choice is a bit of a surprise as it does not align with previous studies on the preference of a dog to watch other dogs over humans, but it may have been that the videos it was competing with were rather dull; that said, in the analysis shown in Table 17, this video was not the highest ranked within its own cluster of videos (G, H, I), which suggests that the others were looked at often in this group but not fixated on. Video D emerged as a clear winner across both analyses—this showed dogs sleeping and relaxing. It is moot to point out that this video was competing with other dog videos.

This analysis indicates that a video that has high viewing times often has very few discrete periods of attention. This is a consequence of the videos with high viewing times being better able to hold the dogs' attention.

7.3.3.7 Change of Attention and Engagement

Over the sixteen interaction sets, Dog A changed his attention from one screen to another a total of 66 times: 7 times in Session 1, 22 times in Session 2, 9 times in Session 3 and 18 times in Session 4. Dog B changed his attention a total of 68 times: 20 times in Session 1, 12 times in Session 2, 18 times in Session 3 and 15 times in Session 4.

The dogs were often seen glancing back and forth between two screens (e.g. Dog A Session 3, Set 1, 1>2>1>2>1>2 and Dog B Session 1, Set 4, 2>3>2>3>2>3>1). This behaviour is described as vision alternation and is seen in humans and animals when searching for interesting information and building up a dimensional 'map' corresponding to the scenery (Carlson et al., 2009). It is possible that these shifts of attention were caused by a flash of colour, a change in brightness, or even a noise, from the other screen—further analysis might reveal what caused a dog to shift attention. As the dogs in this study had near 240-degree vision, some changes of attention may not have been tracked.

In terms of following a video from one screen to another, this was possible on 20 occasions for each dog as there were five transitions per study. Given that often the dogs chose to not participate in viewing events, these transitions were reduced to a possible 11 for Dog A and 12 for Dog B. For these transitions, it was noted that Dog A followed a video across screens on five occasions and remained looking at one screen over a video transition on three occasions. Dog B behaved in a similar way, following videos on four occasions and screens on three occasions. These figures fail to demonstrate an effect for watching video from one screen to another, and given there was a 20-second gap between each set, it would be hard to claim that any following of either aspect (video or screen) is much more than a random occurrence.

7.4 Discussion

The findings from this study have use in two main areas: the first is in the study of dogs attending to media content where the findings can be used by designers of media content for dogs, and the second is in the exploration of methods for use by the ACI community as it seeks to work with dogs (and other animals) in natural, dog-friendly ways whilst also delivering good-quality research. The discussion that follows is in these two parts.

7.4.1 Interactive Media and Dogs

Drawing from the results, it is evident that the content of multiple screens has little impact upon the dogs' watching habits. The dogs did, however, have the longest mean interaction (Table 17) with videos D and

A which were both dog videos, fitting in with previous studies on dogs' preference towards dog content videos (Somppi, 2012). A further point is that despite equally distributing and switching the videos across the three screens, the dogs, even when seeming to favour a video, did not follow those favoured, nor any other videos across the screens. One interpretation from these findings is that if the dog is overwhelmed with too much viewing material and choices, then the dog may prefer to watch nothing. In the study, dogs watched nothing far more than they watched anything although the older of the two dogs seemed able to pay attention for longer. The choice of videos in this study was made based on earlier research but clearly could have affected the results. What is interesting is that according to the analysis of the videos, videos A, C, D, F, J and K were highlighted as particularly favourable to dogs in terms of their media make-up but in the analysis of the data, this appeared to not really have an effect although it is the case that videos A, C and D were quite favoured. In terms of content, the dog videos were certainly quite popular, but the human video (H) was also favoured and did draw the longest single interaction in the study (18.1 seconds).

The study demonstrated that screen position did have some effect in so far as for Dog A, the centre screen was preferred, and also as in many of the video events, dogs changed focus mainly between adjacent screens. The younger dog did not have a preferred screen, but it was also clear that that dog had much reduced interaction times, and so a preference would have been more difficult to identify. With only two dogs, differences would have been expected, and whilst it cannot be claimed that these differences mean very much, the study does draw attention to the need to be aware that dogs will vary considerably in terms of how they attend to media.

The choice to rotate the videos every 20 seconds was justified as there was no single episode of a dog watching for the whole 20 seconds, and there was clear evidence, as shown in Figure 42, that the dogs were primarily only attending to the video for very short periods. This could clearly be caused by the confounds of having three screens in one space, and so it cannot be assumed that dogs would never watch video content for more than 20 seconds at a time, especially in a single-screen layout. However, for this study design, the 20-second choice was appropriate given the aim of the work to investigate screen position, viewing habits and video preferences. The choice of the dogs to not watch and to walk away was expected but was probably higher than was anticipated. This is not the first instance where animals have rejected media technology. Ritvo & Allison's (2014) touch-screen musical interface allowed orangutans to listen to 30 seconds of music or silence but found that the apes preferred nothing. The authors of this study even tried a variety of music from country to more naturalistic sounds, similar to the content change shown in the present study, but still found the same results (Ritvo & Allison, 2014).

7.4.2 Dog-Friendly Animal-Computer Interaction Research

The study proved that the method of tracking the dogs' attention using multiple cameras and then video analysis was effective. The dogs within this study would often lead their watching behaviour with their heads, looking over their shoulders, often not aligning their bodies with their head movements, but even with this behaviour, tracking their faces worked. During intense focus for prolonged periods, the dogs were seen approaching the screen facing the content with their bodies in a straight line, as shown in Figure 38. In addition, there was no evidence of the dogs being disturbed or anxious, and so the experimental study was considered successful. Although no clear evidence was found to show a particular viewing preference, the findings from the study are insightful, and the method has value.

In order for this research to work, the dog had to cooperate with the system. As previously discussed, other researchers have overcome this problem through training and through constraining the dog in some way. The null data in this work, that is, the disengagement of the dog with the interactivity, is as important as the data that shows attention to the media. Each dog chose to not participate in several of the video events, and this has highlighted, in the analysis in this chapter, that this disengagement requires data to be considered in many ways. Whilst the disengagement is very important, the application of means across sessions where there was no attention is a point for discussion. In this chapter, we have shown data normalised for 'active' sessions as well as data that have proven the disengagement ratios. In Tables 19 and 20, where the 'favoured' video per study is discussed, it is important to note that in all but one case, the favourite was in fact 'not watching' a video. Had the disengagement information been stripped from the analysis, there could have been suggestions made as to the favourability of certain videos that would have been exaggerated. When the dogs chose not to participate, they walked off, went to their beds, took drinks, looked out the window, played with toys and did all manner of dog things. All of these behaviours suggested that the dogs were comfortable in the environment, and they supported the decision to make a 'homelike' place for the study given that doing the work in a house would have been problematic for experimental controls.

The method used here is dog-centred by adhering to the principles from Mancini (2011) and within principles for dogs attending to screens and media (Section 3.2.2), by allowing the dog to walk away and effectively withdraw consent. That, similar to the findings of Ritvo & Allison (2014), the dogs overall preferred to not attend to the technology is itself an important finding. This lack of attention in this instance could be due to the design of the current technology, to the choices of videos, to the three-screen design of the work or simply to the fact that the two dogs in the study did not like watching TV.

7.5 Conclusion and Future Work

Within this work, we aimed to determine if dogs could choose what to watch on TV-style screens, to determine what they preferred and to see if a method could be designed to study this area that was dog-friendly in so far as it allowed dogs' autonomy and gave them a secure feeling. In the case of the latter, the research shows that this was achieved, although it did result in there being a considerable amount of time when the dogs did not attend to the screens. This trade-off is to be expected in ACI, especially where the studies are around entertainment-style systems that are neither repetitive nor reward based and so allow considerable freedom, to the animal, to not engage. Perhaps the main contribution from this work is that the time a dog is not doing the main effort of a research is as important as the time spent attending specifically to the research.

The study provided some insights for those seeking to develop interactive media for dogs. The findings confirmed that dogs were happy to watch dogs. They showed an age effect for time on task, highlighting that younger dogs may give different findings than older dogs. They showed that there was some evidence that dogs turned from one screen to an adjacent one and that there was some positional preference within a three-screen system. The study also demonstrated a considerable range of attention times possible. The main limitations of the work are in terms of the decision to study only two dogs and in the use of the technology, which was not exactly the same as TV technology. Clearly more dogs would each have added more insights. In terms of the technology, as the computer screens were only truly visible at eye height, the three screens had to be lowered to the dogs' eye level, which may not be a typical 'at-home' setup for a TV.

The work here is a starting point for two divergences. The first will be to create an interactive technological system where the dog is able to turn on, and turn off, the video on a given screen, as explored in the next chapter (Chapter 8). Two screens could also be implemented, and a follow-on study will test between dog-favoured content and a distractor to see if the dog follows the dog-favoured video. This could be tested with a wider range of dogs and with dogs of varying ages. A Wizard of Oz technique could be used in such a setup to prompt a change in video content when a dog moves away from, or approaches, the screen. The second main work will be to further develop ways and environments that allow the dog to be studied and to participate in research whilst still remaining free to walk away, lie down, not conform, etc., and is the focus of this thesis.

In conclusion, a system in which to test dogs' viewing habits, favouring and following videos by using three screens, has been described, and the findings have been presented. The findings provide initial evidence that when dogs are presented with three screens, they are unable to follow through three-screen variations on what to watch. There is a possibility that a central placement is the preference. On average, the dogs had a low mean view time per interaction and seemed content to glance across the multiple screens. Overall, even though the content subject within the videos was different and proved to be appealing to the dogs, the dogs, when confronted with three-screen options, preferred to watch nothing.

In the field of human-computer interaction, much is made of experimental results that show how one technology is favoured over another. In these studies, human participants come to an experiment or an observation and 'do as they are instructed', that is, they typically engage first with one and then with another technology and measures are taken. The work in this study has highlighted that 'non-conformance' to researchers' aims can result in very valuable insights. The dogs in this study chose to not watch TV over any TV content; even *Coronation Street* failed to hold their attention, which rather suggests that TV watching, for dogs, may be much less fun than wandering around, eating, taking a drink, sleeping and playing with toys.

Overall, this work fits into the body of this thesis through building and testing a method of monitoring dogs' attention habits with multiple screens, to help build on the current methods proving ACI with dog-friendly ways of researching within the dog-friendly-centric ethos that this thesis advocates.

7.6 Contributions Derived from the Study

- A dog-centric method to test dogs' viewing habits, favouring and following between TV-style screens to see what they prefer.
- When dogs are presented with three screens, the findings confirmed dogs are happy to watch other

dogs.

- Dogs have very low mean attention time to video, demonstrating a preference to glance rather than focus demonstrating a range of attention times.
- When confronted with three screens, the dogs prefer to watch nothing over all the videos shown highlighting the contribution that the time a dog is not doing the main effort of research is as important as the time spent specifically to the research.
- Findings suggested an age effect highlighting that younger dogs may give different findings than older dogs.
- Showed some evidence that dogs turned from one screen to an adjacent one and that there were some positional preferences within the system.

Chapter 8

Study Three: DoggyVision: Examining How Dogs Interact with Media Using Proximity Tracking

8.1 Introduction

This chapter forms an overarching research thread throughout this thesis by pulling together findings and methods from the previous chapters on dog-screen interaction to test in an ethnographic dog-centric manner an automated media device for dogs: DoggyVision. This concluding study aims to contribute towards the three evaluating methods within ACI: researchers, owners and the dogs themselves covering the bases touched upon previously. The Java program used to record and display media within this research was coded by Dr Brendan Cassidy for this study.

Whilst screen technology and media is designed for dogs to view, there is a lack of research showing to what extent, and for how long, dogs attend to screen media. One pressing question is to understand if a dog, given the choice, would or could use an automated TV screen device to control viewing. This chapter describes a prototype system (DoggyVision) to explore giving control to a dog in regards to the turning on and off of a TV screen and to study interaction with screen media in home settings. DoggyVision was shown to be non-invasive for the dog and easy to use in the home. Recordings showed that dogs did attend to the screen but did not appear, in this study, to change their behaviours around the TV screen between being in some control of, and in no control of, the TV media presentation.

Since 2009, the Californian TV channel DogTV has claimed a growing audience (30 million) worldwide.

Companies like DogTV have an interest in understanding not only what the dogs watch but also whether dogs can choose media and whether, given appropriate technology, they would choose to turn media on and off.

The 2015 PDSA PAW report (a study of animals in the UK) suggested that out of a UK population of 9.3 million dogs, over 3 million were left alone in their owners' homes for quite a considerable length of time. Coupling this demographic with the increase of consumer systems for dogs, it is clear that technologies in the home, for dogs, could be societally beneficial. For the research community, the study of such technologies can provide important insights into the design of user interfaces (UI) for dogs and can contribute insights towards the dogs' attention with screen devices.

Humans' viewing habits and experiences with television and media devices are typically investigated by using tracking of the attention of the viewers to the screen, using logged data of channel and content selection activities and using self-report from the viewers regarding their viewing habits (Raynor et al., 2013; Abreu et al., 2014). Surrounding this, there are innovations and methods including the Fraunhofer FOKUS "TV Predictor" (Krauss et al., 2013), with multiple input modalities available for controlling screen devices (Bobeth et al., 2014). To carry out a self-report study with dogs, the use of surveys can only be done where there is a proxy for the dog (typically an owner as investigated in tool 2[Chapter 5]), and the use of selection of channels as a method for study is not possible as the dog cannot (to date) select, and so the use of tracking of vision and attention is the only method that is dog-centric. Animal-centric (and by association, dog-centric) research is a main theme in ACI as it tries to understand the animals' needs and design around the animals' requirements (Chapter 3; Mancini et al., 2016).

Eye gaze tracking has shown that dogs can view screens showing both images and videos (Somppi et al., 2012; Williams et al., 2011) with these studies demonstrating similarities in gazing behaviour between dogs and humans (Tornqvist et al., 2015). Given that dogs have been seen to attend to media, the question is raised: would a dog use and activate a specially designed dog screen control device? Research has been done to show dogs using screen devices (Zeagler et al., 2016) and suggest what they would like to watch (Section 2.7; Somppi et al., 2012), but given a choice, would a dog use an interactive device, recognise how the device is activated and look at a TV device?

This chapter presents a study describing and evaluating an automated screen device for dogs, coined DoggyVision, that allows a researcher to investigate the dog's behaviour with a media screen in a home setting over a period of a week (or more). This DoggyVision system is being suggested as both a way of tracking system activation behaviour and as a way of exploring giving a dog control of a device.

The impetus for a dog-driven media system is to further explore how dogs use screen devices to build the groundwork of DCI methods exploring dogs' use of friendly screen systems within this context as narrated throughout this thesis. Systems, like the one presented here, could provide entertainment to dogs left alone or could provide a method of communication between dog and screen. Whilst the DoggyVision DCI system has an initial niche focus on dog users, the encompassed method has implications towards both ACI and HCI through the transferability of methods and ideas. This chapter takes a known HCI method of an activation area and studies this concept with dogs making alterations to fit the end user's requirements.

When methods are altered, new knowledge is created that others can use, both in the animal and human field strengthening both instances. It is through exploring this method transference and encompassing technology instances that the real value is held within this chapter.

8.2 DoggyVision

The DoggyVision system plays preselected media to the dog when the dog is detected in front of the screen, otherwise remaining blank. When activated (i.e., when a dog is in front of the screen within the activation space), the DoggyVision system films the activation of the dog with the screen and packages this in such a way that it can then be later analysed. A log is made of when the dog is in the sensed area, and this data can give information about lengths of activation. The DoggyVision system is novel in enabling dogs to have self-activated instances with media without any need for training.

8.2.1 Hardware and Software

The DoggyVision system is made up of the hardware, the software and the installed media. For the purposes of research, allowing a control setting, it operates in two modes, mode one, which is tracking only, and mode two, which is track and play. In both cases, the system records videos of the activity in front of the screen when the tracked area is moved into.

Figure 43. DoggyVision setup.

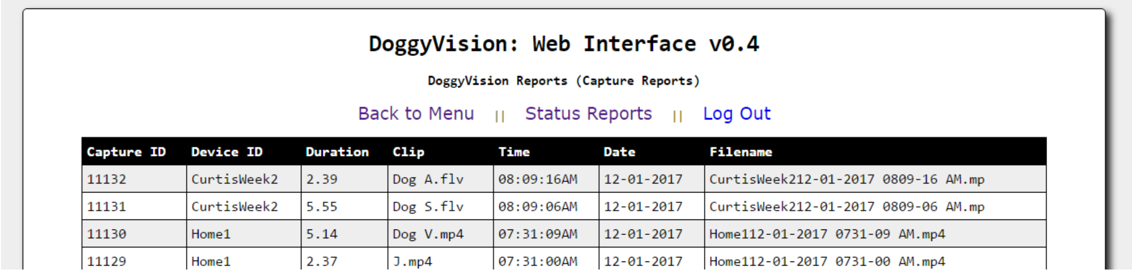
Whilst any screen and computer would work for DoggyVision, in this case the hardware used was a single monitor (HP L9600) positioned at head height for the dog following the previous work and study 2 (Chapter 7) guidelines. A webcam (Logitech HD720p) is positioned above the screen in a central position to capture the activity in and around the activation area, two PC speakers (creative SBS 260) output sound with the volume set to 25% to be audible but not so loud as to frighten and cause distress to the dog and an Arduino tracking/sensing device. This resulted in the setup as shown in Figure 43.

The software created for the DoggyVision device, written in Java, controlled the delivery of media clips

(FLV files), the recording and processing of the Arduino input from the sensors, the local and online saving of status reports and the option of recording the activation through video recordings (Figure 44).

Figure 44. Main menu screen of DoggyVision v1.2 showing options and media clips with second picture displaying the web interface which recorded capture details and device status reports.

The web side of the device (as shown in Figure 44) displayed capture reports (Figure 45) and status reports (Figure 46) of the device.

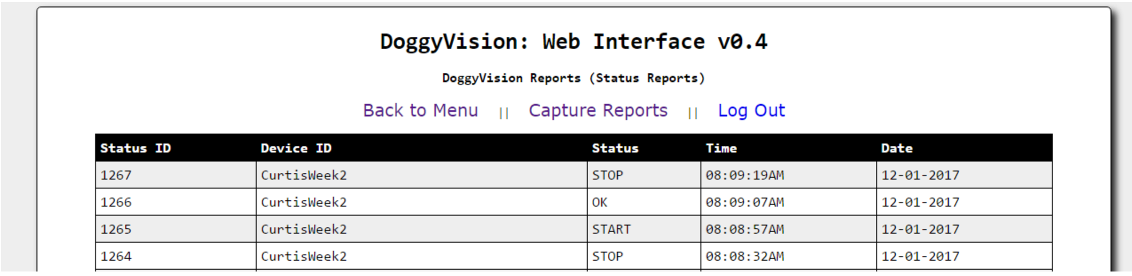

DoggyVision: Web Interface v0.4

DoggyVision Reports (Capture Reports)

Back to Menu || Status Reports || Log Out

Capture ID	Device ID	Duration	Clip	Time	Date	Filename
11132	CurtisWeek2	2.39	Dog A.flv	08:09:16AM	12-01-2017	CurtisWeek212-01-2017 0809-16 AM.mp
11131	CurtisWeek2	5.55	Dog S.flv	08:09:06AM	12-01-2017	CurtisWeek212-01-2017 0809-06 AM.mp
11130	Home1	5.14	Dog V.mp4	07:31:09AM	12-01-2017	Home112-01-2017 0731-09 AM.mp4
11129	Home1	2.37	J.mp4	07:31:00AM	12-01-2017	Home112-01-2017 0731-00 AM.mp4

Figure 45. DoggyVision: web interface showing capture reports. These were displayed with a capture ID; device ID; duration; clip (media being played); time (of capture); and time, date and filename (of video being captured).


DoggyVision: Web Interface v0.4

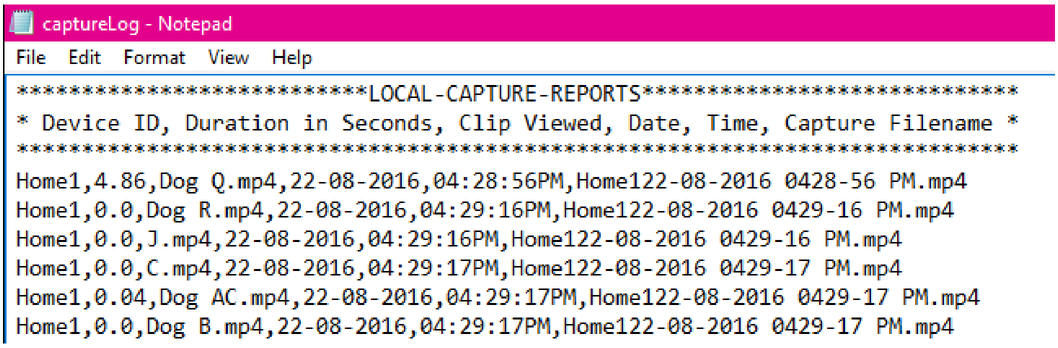
DoggyVision Reports (Status Reports)

Back to Menu || Capture Reports || Log Out

Status ID	Device ID	Status	Time	Date
1267	CurtisWeek2	STOP	08:09:19AM	12-01-2017
1266	CurtisWeek2	OK	08:09:07AM	12-01-2017
1265	CurtisWeek2	START	08:08:57AM	12-01-2017
1264	CurtisWeek2	STOP	08:08:32AM	12-01-2017

Figure 46. DoggyVision: web interface showing status reports. These were displayed as DoggyVision being started and stopped.

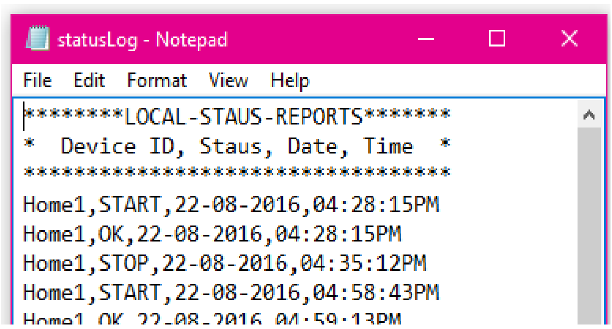
These capture reports were also available locally through the capture log (Figure 47) and status log (Figure 48) saved within the software itself.


captureLog - Notepad

File Edit Format View Help

```
***************************LOCAL-CAPTURE-REPORTS*****************************
* Device ID, Duration in Seconds, Clip Viewed, Date, Time, Capture Filename *
*****************************************************************************
Home1,4.86,Dog Q.mp4,22-08-2016,04:28:56PM,Home122-08-2016 0428-56 PM.mp4
Home1,0.0,Dog R.mp4,22-08-2016,04:29:16PM,Home122-08-2016 0429-16 PM.mp4
Home1,0.0,J.mp4,22-08-2016,04:29:16PM,Home122-08-2016 0429-16 PM.mp4
Home1,0.0,C.mp4,22-08-2016,04:29:17PM,Home122-08-2016 0429-17 PM.mp4
Home1,0.04,Dog AC.mp4,22-08-2016,04:29:17PM,Home122-08-2016 0429-17 PM.mp4
Home1,0.0,Dog B.mp4,22-08-2016,04:29:17PM,Home122-08-2016 0429-17 PM.mp4
```

Figure 47. DoggyVision: web interface showing capture reports. These were displayed in a list through capture ID; device ID; duration; clip (media being played); time (of capture); and time, date and filename (of video being captured).


statusLog - Notepad

File Edit Format View Help

```
********LOCAL-STAUS-REPORTS*******
*  Device ID, Staus, Date, Time  *
**********************************
Home1,START,22-08-2016,04:28:15PM
Home1,OK,22-08-2016,04:28:15PM
Home1,STOP,22-08-2016,04:35:12PM
Home1,START,22-08-2016,04:58:43PM
Home1,OK,22-08-2016,04:59:13PM
```

Figure 48. DoggyVision: web interface showing status reports. These were displayed in a list showing device ID, start or stop, and date and time.

DoggyVision Java software can be found in Appendix 5.1 in its entirety.

8.2.2 Media Clips

Numerous researchers have investigated dogs' preferences in regard to visual media (Williams et al., 2011; Somppi et al., 2012; Tornqvist., 2015) showing that dogs attend to the screen when other dogs are being displayed. For this reason, for DoggyVision, 39 media clips were chosen with each showing varying dogs in different situations in the aim of providing interesting content. These media clips had previously been shown to an even-tempered dog who showed no distress or violence in seeing them. For the purposes of the research study, when activated, the DoggyVision device chose media clips from the 39 at random to minimise any effect of the media content on the dogs' attention habits.

8.2.3 DoggyVision Tracking

The DoggyVision tracking device combined an Arduino microcontroller with two infrared (IR) distance sensors (Sharp GP2Y0A02YK) (Figure 51), to create a 100 × 20 cm (horizontal) activation area in front of the screen on which the sensor is placed. The IR distance detectors were placed 15 cm apart to allow for the largest activation range.

8.2.3.1 Building DoggyVision Tracking Technology

IR range detectors were chosen in this instance after testing the DoggyVision tracking and media delivery system with IR motion detectors and ultrasonic sensors. For DoggyVision tracking, ultrasonic sensors (HC-SR04) were found to be hard to use because of the dogs' fur preventing accurate sound reverberation and worries over the dog hearing this sensor within their audio range (Figure 49). Although the range of these devices is large (4 meters), it did, however, often result in ghost echoes off nearby reflective objects (hard surfaces) frequently being read instead of the dog (soft fur). If this method was to be continued to be used in DCI projects, the researcher would need to ensure that the device used was outside of the auditory range, and the dog was given a wearable device, ideally, to allow for effective sound reflection.

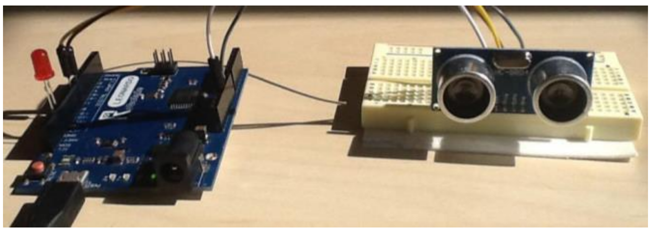


Figure 49. Setup for Doguino ultrasonic device

Whilst IR motion sensors (tested HC_SR501 body sensor module) in laboratory settings work well (Figure 50), with an adapted cardboard cone, how a dog normally interacts with screen device is through a series of pauses and motions. This would result in the dog stopping being detected when they paused to watch the media clips. A device like this, therefore, could be used as an initial interactor but not as a continual tracking sensor. The advantage of this device, however, was that cardboard cones were placed upon the two PIRs so that motion could be sensed at two heights (human and dog) allowing a diffraction between the two entities movements.

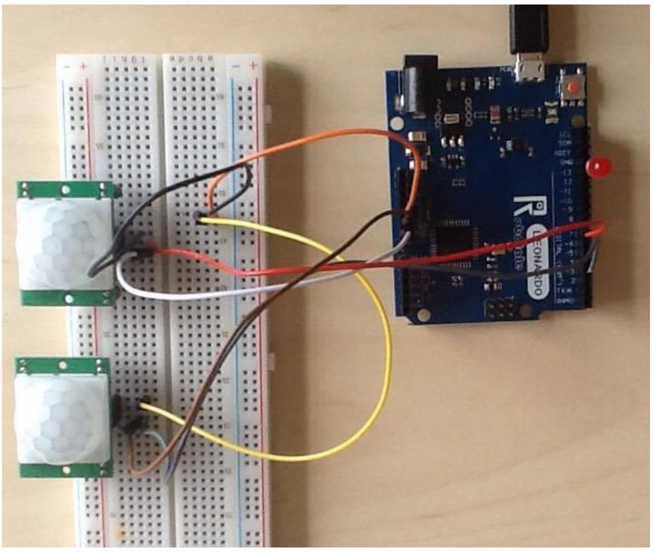


Figure 50. Setup for Doguino PIR motion detection using two PIRs, Arduino Leonardo and LED.

Whilst testing IR motion detectors, it was found that the dogs would often pause to watch the screen; thus, the DoggyVision device would turn off limiting the interaction even though the dog was still attending to the screen. IR range detectors therefore allowed for the dog's own ordinary behaviour (of proximity) whilst presenting available solutions of interactivity detection for DoggyVision tracking (Figure 51).

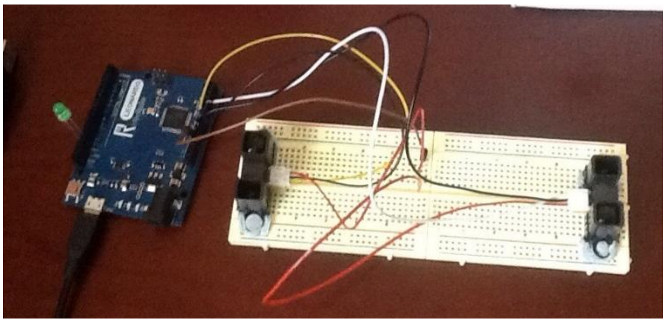


Figure 51. Setup used for DoggyVision infrared (IR) range detecting with two Sharp 2Y0A2 range finders.

Two IR range detectors were chosen to use to give a larger reading area, as IR range detectors have a limited interaction space. Detection with IR readers can have false readings; reportedly 12% of Sharp IR readings give a value with up to over 42% of the distance (Doggen, 2014), compounded when using multiples as in this instance (Hermann et al., 2012). To achieve accurate results and prevent these false readings, the proximity readings were averaged out over 25 readings to make sure these 25 readings were within a 93-cm range of each other following Doggen (2014) Arduino Sharp IR guidelines. By implementing these two checks of averaging out the incoming IR readings and a delay on detection, this enabled the setting up of a DoggyVision tracking device within the dog's parameters.

The DoggyVision system was initially tested with one dog; Dog A. During this test, it became apparent that the way a dog moves with proximity devices is very different from that of human movement. For instance, a dog's tail wag movement happening in the sensed area would result in the dog being detected and undetected quicker than the software could process logging and saving the activation data, causing DoggyVision to crash. Taking from the study 2 (Chapter 7) research that reported dogs' average screen interactions, the software was adjusted to work with three-second intervals of activation. Thus, within each three-second period, the media continued to play – at the end of the period, the software checked for a dog, and if the dog was there, the media continued for another three seconds. This resulted in three-second iterations of activations, that is 3, 6, 9, etc., seconds of media playtime hereon referred to as media iterations.

There was a slight delay between the keypress being detected by the DoggyVision tracking device and the media clips randomly being selected, loaded into memory and played on the screen. As such, the timings recorded by the DoggyVision software are only taken for the duration that the media clip is being played on the screen and not when the keypress has been detected. This, paired with the slight delay implemented earlier to prevent software crashes, resulted in an overall 2.98-second delay being implemented of media playtime overall with no false positive results.

To allow the dog to use the space without deliberate activation, the DoggyVision system was positioned at the dog's body height associated with the dog's biggest body mass. This allowed the dog to sleep (lay down) within the space without being disturbed by the DoggyVision system. It is in this manner that this DoggyVision system was designed to be dog-friendly whilst still able to collect data. This resulted in the following setup (Figure 52).

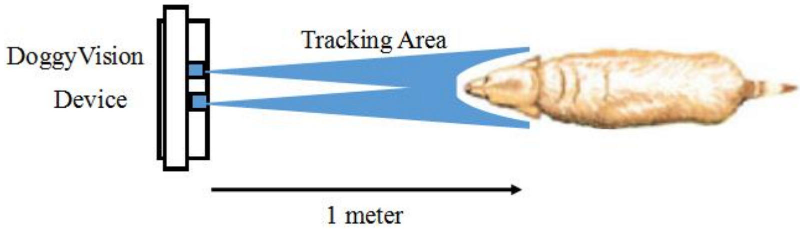


Figure 52. Setup used for DoggyVision using IR.

8.2.4 Classification of Interaction and Activation

Within this work, an activation is a capsulation of a dog interacting with a screen, but what is classified as an interaction within animals has not clearly been defined as little is known behind the meaning of context of the relationship between the animal and the objects designed for them (Section 3.2). Following typical archetypal structural canonical models of HCI, there needs to be a feedback loop as suggested in Norman's "gulf model" of interaction (Norman, 1988) as pictured in Figure 1. As in Norman's model, the "gulf" in animals is even more so within the execution as the intentions behind the action specifications are often unknown, particularly in nontrained systems. As the designed DoggyVision system reacts to input and is uncertain if the transfer function (coupling of input and output) is dynamic within this system, that is, holds meaning or goals to the dog, the system's instances are defined as activations rather than interactions within this work. It is unknown if the activation attention shifts are on a conscious interaction level.

8.3 DoggyVision in the Home

The remainder of this chapter describes the use of DoggyVision in the home. As this is the first study of this sort, as well as there being interest in the data generated, there is also a contribution from understanding the approach in terms of its usability in dog-computer systems.

The DoggyVision system was placed inside the researcher's home for two periods of two weeks. In each period (one for Dog A and one for Dog B), the system was placed for one week with the screen and sound output turned off (mode one – track) and one week with the system fully functional (mode two – track and play). With technology, such as home-based media devices, like TVs and computer screens, laboratory experiments are not appropriate, as such products engage with the way people, and animals, live (Olsen et al., 2014). Installing DoggyVision in a home environment allowed for the first week to be used to build up a baseline of movement for the room being used so this could be then compared against the second week when the DoggyVision system was turning on the media clip as the dog approached. In this way, the study was dog-friendly, stepping away from trained responses and allowing the captured data to come directly from the dog end user.

In each case, after the DoggyVision system was used in the house for the two weeks, owner observations on their dog's use of the device were noted to gain further context behind the activations. To enable further context analysis, the doggy information sheet (DISH) was used before the system was installed (Tool 2 [Chapter 5]) as a reminder for the researcher (owner of Dog A) and to Dog B's owner. DISH has been shown to aid owners in reporting not only their dogs behaviour but also, importantly, when quantifying the dogs experience, the motivation behind their dog's behaviour in an informed observer HCI manner (Tool 2 [Chapter 5]). Dog B's owner used DISH when watching his dog's behaviour from the captured videos to give comment on Dog B's behaviour and towards initially describing his dog.

8.3.1 The Dogs and the Home

As in earlier studies, the two dogs included in this study were Dog A and Dog B as referred to in Chapters 3 and study 2 (Chapter 7). At the time of the study the dogs were 61 months (Dog A) and 24 months (dog B) old. Dog A was 136 cm and Dog B 120 cm long from nose to tail (activation height), with dog A being 22 cm at its thickest point and Dog B being 18 cm (see Figure 53). In line with ethical principles in ACI (Mancini, 2016; Chapter 3), and to provide as natural a setting as possible, the studies were conducted in a familiar environment for the two dogs. As Dog A and Dog B were both familiar to the researcher, with Dog A living, and Dog B often residing, in the author's home, the location used for this study was the researcher's home. This resulted in no variability of study settings (between the two dogs) but the study design allowed for variability between the dogs by which the dogs' behaviours with the track and play mode (mode 2) were compared with their activities in week one (mode 1) rather than them being compared across study locations.

It is worth noting that within the study, the dogs could walk away from the DoggyVision system whenever they wanted and could therefore choose to not interact with the DoggyVision system. This is to enable a form of consent over participating within the study from the dogs themselves (Mancini, 2016; Chapter 3).

Figure 53. Dog A (left), a 61-month-old male Labrador; Dog B (right), a 24-month-old male Labrador.

The daily activities of the dogs and owners, such as walks, were kept similar during each two week study to reduce the variability of the time. It is in this way that changes in the variabilities were minimalised where possible.

8.3.2 Data Analysis and Interpretation

In each instance, data was not only stored locally but also sent to a server. In this way, any lags in storing data and any system failures would have been noted. In the event, there were no system failures. The process for analysis required three stages: cleaning and verification, coding and then comparisons.

To begin with, the data was cleaned by analysing the recorded local and online time/interactivity data against the captured video recordings associated with each activation timing. This bringing together of the two sets of data was necessary to ensure that the activation gathered was dog-initiated. Any logs of nondog activations, and any recorded videos of nondog activity were removed at this stage. At the end of this process, the data was considered to be made up of a series of 'dog activations' where an activation represented the triggering of the DoggyVision system by a dog who was within the detection range.

In the second phase, the recorded video associated with each dog activation was analysed to determine whether or not the dog was looking at the screen. 'Not looking' viewing was defined as when the device detected a dog within the activation space, but the dog was not actively seen to attend to the screen. 'Looking' was defined as when a dog was seen to look at the screen at any time during the activation. This coding scheme was verified by having three researchers analyse a small sample of recorded videos (5 from Dog A; 15 from Dog B) from week 2, where the dog was seen to watch the screen. These sampled recorded videos were chosen at random using the Haahr (2016) random number generator.

Having coded the data, the data was then scrutinised within dogs (week 1 vs. week 2) and between dogs (Dog A vs. Dog B). Counts were made of the number and type of the different activations (looking and not looking codes), the activation lengths (in terms of the number of continuous media clips played by the DoggyVision system), the range of activation durations, the average number of daily activations and the total (overall) (week 1 and week 2) activation time.

In interpreting the data, it is important to understand what could be happening. Where there is a three-second (one media play) logged dog activation, this could either represent a single activation, where the dog enters and then leaves the tracked area before the end of the media clip, or a multiple activation, where the dog might enter, leave and then re-enter and leave although theoretically this would be quite hard for a dog to achieve in a three-second time. In a longer dog activation (e.g., 6 seconds or 9 seconds), it could be that the dog enters and remains (leaving at some point in the last three seconds, thus affecting the end of the media stream) or that the dog enters and leaves and re-enters in such a way that the leaving and re-entering is within a three-second media clip, and thus, there is an impression that the dog is always there. The detail of this can only be discerned by looking at the video of the dog activations.

8.3.3 Results

The results are presented here beginning with an overall summary of the data within this study (Table 21 and 22) and key findings. Due to extraneous variables, definitive conclusions cannot be drawn, only initial data partly due to the sample size but this data does provide some insight.

The data is derived from three sources: information derived from the DoggyVision device software logs, from the video data and from the owners themselves. Table 21 shows that over the two weeks of the study, Dog A behaved quite similarly with little change in the number of activations. Unsurprisingly, Dog A looked at the screen much more when the screen was displaying media (week 2).

	Dog A		
	Week 1	Week 2	Difference
Initial Interactions (7 days) (number)	573	534	-39
Owner Interactions	47	37	-10
Dog Interactions	490	497	+7
Average Number of Dog-Interactions Per Day	70	71	+1
Total Interaction Time (seconds)	3047.4	3377.4	+330
Not Looking Interactions	489	382	-107
Looking Interactions	1	115	+114
Longest Interaction (media iterations of 3 seconds)	18	18	0
Shortest Interaction (media iterations of 3 seconds)	1	1	0
Mean (media iteration of 3 seconds)	1	1	0

Table 21. Summary of DoggyVision Data with Dog A.

	Dog B		
	Week 1	Week 2	Difference
Initial Interactions (7 days) (number)	2128	1895	-233
Owner Interactions	49	54	+5
Dog Interactions	2079	1841	-238
Average Number of Dog-Interactions Per Day	297	263	-34
Total Interaction Time (seconds)	14616.6	13741.2	-875.4
Not Looking Interactions	2076	1459	-617
Looking Interactions	3	382	+379
Longest Interaction (media iterations of 3 seconds)	52	36	-16
Shortest Interaction (media iterations of 3 seconds)	1	1	0
Mean (media iteration of 3 seconds)	1	1	0

Table 22. Summary of DoggyVision Data with Dog B.

Dog B had a higher percentage of screen watching than Dog A (Table 22). The number of dog activations went down slightly for Dog B from week 1 to week 2. As with Dog A, Dog B looked at the screen more when the screen was playing media.

From these two tables of data, it can be presumed that dogs will look towards a dog screen device if placed within their home and is playing media. However, these results also show that dogs will not always attend to the screen even when it is on (the suggestion here is that they attend as little as 21% for Dog B and 23% for Dog A).

Both dogs interacted with the DoggyVision system differently. There were ‘looking’ behaviours seen in both dogs within week 1 due to the dogs looking towards the device even though it was not turned on. Dog A had on average 70 activations per day within the device space; Dog B had a higher average number of 297 (Dog A totalling 987; Dog B 3,920 activations over two weeks) (Table 21). This resulted in Dog B appearing to be almost three times more interactive than Dog A. The difference within these numbers can partially be due to the age differences and the activeness of the dogs as Dog A was noted as lazy and Dog B as very active by the owners. Other factors could include the layout of the home; it could be that Dog A was generally less inclined to go into the room with the DoggyVision device in than Dog B was.

Due to the system being in place for 14 days, it was also possible to track the dogs’ activations over time (Figure 54).

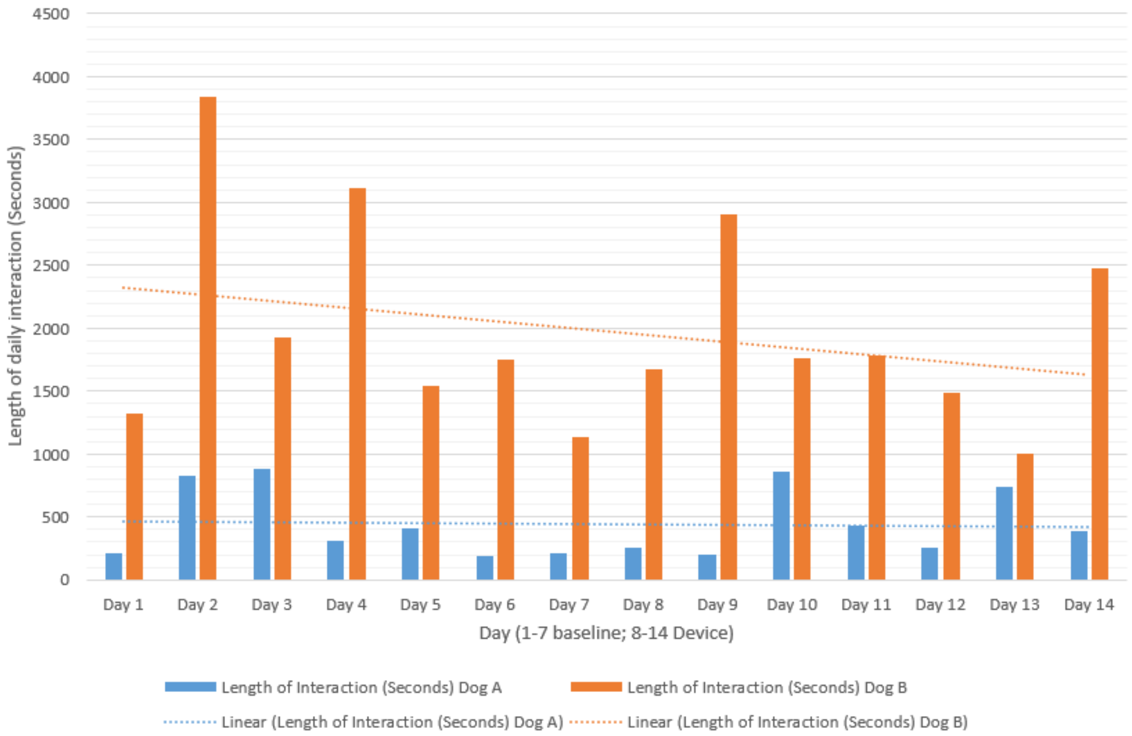


Figure 54: Graph showing Dog A and Dog B interaction over the 14-day study period (1–7 days without the screen turned on and 8–14 with the screen turned on) including a linear plot line.

As this graph shows, the activation time Dog A and Dog B had whilst using the DoggyVision device varied daily. Dog A, however, from week 1 to week 2 (day 1 vs. day 8, day 2 vs. day 9, etc.) had high and low interactivity on similar days, once again pointing to a similar usage from week 1 to week 2. Dog B, however, not only has less usage (as seen from the linear line) but also its interactivity has greater spikes varying more daily towards a downward slope. This data shows that a dog's interactivity varies daily. This variation could be due to the rhythm of the house in which the dog lives, because of certain behaviours of the owners, or could be just about the dog. It demonstrates the need to install media tracking devices over a reasonably long period of time to gather data.

8.3.3.1 Understanding Dog Interactions

The 'looking' and 'not looking' coded activations, defined as a dog being seen to focus on or not focus on the screen changed from week 1 to week 2. Whilst the timings of the data are within iterations, they are comparable across weeks because of the same system being in place. Clearly both dogs looked much more at the device in week 2. These results show that the dogs did focus on the screen when there were media clips playing, that is, they attended to the media.

Observing further into this data, the devices caused a change in the looking behaviour of the dog. Dog A had an 31.84% increase in looking behaviours and Dog B a 32.21% increase (Table 23).

		Week 1		Week 2	
		Time (Seconds)	Percentage	Time (Seconds)	Percentage
Dog A	Looking	3.14	0.10%	1002.12	31.94%
	Not Looking	3044.15	99.90%	2135.24	68.06%
Dog B	Looking	12.59	0.09%	4437.99	32.30%
	Not Looking	14603.91	99.91%	9303.11	67.70%

Table 23. Percentage of 'looking' and 'not looking' codes between week 1 and week 2 with DoggyVision for Dog A and Dog B. Percentages rounded to two decimal places.

These results show that, similar to study 2 (Chapter 7) results, the dogs overall preferred to not watch the screen than watch the screen, but having the DoggyVision system operational with media clips being played did cause a 32% increase in looking behaviour.

By analysing the video of the dog that was captured by the DoggyVision camera, it was noted that nonattendance to a played screen was often seen when the dog was already preoccupied, such as running around with a toy, preparing for a walk, chewing things or otherwise currently engaging with other behaviours. This choice of the dogs to also choose to ignore the device does help verify the dog-friendly aspect of the method and technology, as this approach enabled the dog to engage in other behaviours without dominating or causing a negative behavioural effect.

Whilst analysing the datasets, it was noticed that both dogs displayed similar activation behaviour between 'looking' and 'not looking' codes. This behaviour noted was that dogs involved would often go through periods of 'looking' at the screen before going back to 'not looking' for a certain period rather than random 'looking' and 'not looking' periods as almost 'glances'. From this behaviour, it can be hypothesised that with interactive media devices, dogs go through periods of looking and not looking helping build up a pattern of interactivity in DCI media.

To investigate this further, we took six random activations using the Haahr (2017) number generation, three from Dog A and three from Dog B from week 2 whilst the device was on, to try and elicit why a dog would be constantly within the activation space. These activations were picked to be randomly selected between below 4 seconds (short), 4–15 seconds (medium) and >16 seconds (long) to provide a range of accounts.

89.3.3.2 Dog A's Activations with DoggyVision

Dog A's activation (3 seconds) was screen walking across the activation space (left to right) carrying a toy wagging vigorously.

Dog A's activation (12 seconds) began with the dog walking and then stopping standing horizontal to the device with his face towards the screen looking at the device. Dog A moved his head up and down and then quickly looked behind himself away from the screen turning back to face the screen. He then stepped with his front paws out stretching towards the screen looking towards the right of the screen and walking out of the activation area.

Dog A's activation (47 seconds) approached the tracking area from the left standing with only the front half of his body within the tracking space focusing his attention on the owner on the other side of the room and gazing around the room. After 18 seconds, dog A turned his head around to focus on the DoggyVision device pricking his ears and wagging. Dog A then moved his head closer towards the device continually moving, pricking up his ears and glancing around the screen space. After 32 seconds, the dog looked back towards the owner lowering his head, looking around the room before laying down slowly, putting Dog A out of tracking range.

8.3.3.3 Dog B's Activations with DoggyVision

For Dog B's activation (3 seconds), he was seen to walk into the activation space from the left looking forward and quickly sitting down placing himself out of the tracking space.

Dog B's activation (9 seconds) began with him walking into the tracking space from the right-hand side stretching and carrying a rubber toy. He then stopped stretching, dropping the toy (4 seconds) and sitting down facing away from the device turning his head (7 seconds) towards the screen and watching the device from over his right shoulder before walking off to the left towards the toy box.

For Dog B's activation (108 seconds), he approached the DoggyVision screen from the left side looking towards the door and sniffing on the floor before looking back at the device, walking closer to the screen and sitting down looking towards the dog owner on the left. At 38 seconds, he turned his head to face the device pricking his ears, looking away quickly and then focusing back towards the device. He then held his attention towards the device raising his head with his ears pricking up and down continually. At 52 seconds, he looked back at the owner, still sitting, then down at the floor at 59 seconds and back at the device after 62 seconds. He was then frozen and stared directly at the screen before walking away towards the owner to end the interaction.

This analysis demonstrates both dogs were seen to stay within the activation space and show certain behaviours, such as pricking of the ears and head movements either lateral or moving their head towards the device. Dog A ended the activations by laying down, whilst Dog B walked away from the device.

8.3.3.4 Owner Reports

The researcher and the owner of Dog B did not report any notable changes in their dogs whilst using this DoggyVision system. Whilst the researcher clearly saw both Dog A and Dog B watching the DoggyVision screen, she never saw the dogs consciously trying to activate the DoggyVision tracker. Dog B's was seen to growl at the DoggyVision device once for unknown reasons but, other than that, did not display any aggressive behaviour towards the device. Dog A was noted to be very interested in smelling the DoggyVision device when it was first brought into the house. Dog A would often set off the DoggyVision tracking device with his tail and then go to freeze when watching the DoggyVision system causing his body to become out of range turning off the tracking device, which resulted in the dog resuming wagging and the process repeating. Dog B's owner upon enquiring into the findings indicated that his dog (Dog B) preferred to watch animals from his observations and wondered if that was an impacting factor.

8.4 Discussion

The findings from this study have use in two main areas; the first is in the study of dogs attending to a specially designed dog media product, DoggyVision, and the second more interesting inquiry is in the exploration of methods and devices for use by the ACI community. This method seeks to work with dogs (and other animals) in their ordinary environments in a friendly way whilst deriving good quality data. The following discussion will follow these two themes whilst situating the results found here with others in ACI.

8.4.1 What Was Learned about Dogs and TVs

It is evident from these results that the two dogs behaved differently towards the DoggyVision system. One of the key contributions to come from this study was that the DoggyVision system theoretically could allow a dog to control their own watching of media whilst additionally recording this activation. The DoggyVision system was shown to work with two different dogs over a longitudinal period without human intervention. This demonstrates that dog driven systems are possible within the user-centric philosophy (Section 3.2.2). The study did demonstrate that the dogs involved did attend to some of the media that was shown by the DoggyVision system shown through the increased looking behaviour seen during week 2 of the study.

Whilst Dog A had similar activation times and numbers over the periods of with and without the media being played, Dog B, over the two-week period, had slowly declining activations showing a slight preference towards not interacting with the device. However, both dogs had a similar increase in looking behaviour, if not within activation numbers, between weeks. This method therefore of proximity measurements as an input space could give dogs a more ordinary method of tracking rather than trained paw or nose reactions as used in Geurten et al. (2015) and Zeagler et al. (2016) work. This does come at a cost towards the method, however, as the activation times are not precise but within iterations.

Dog B interacted almost three times as much as Dog A with DoggyVision. This was suspected to be due to Dog B being much more active than Dog A and also indicated, as discussed in study 2 (Chapter 7), that the age difference between the dogs (Dog A being 5 and Dog B being 2 years old) has an impact on the activation numbers. This would need to be investigated more for validity, however.

This activation seen by dogs did change daily in dissimilar patterns for unknown reasons. The reasoning behind the daily activation varying was unknown. From the results, it appeared that the dogs would go through high and low interactivity periods of continually setting off the device. This could be for many reasons including that the dogs were continually within the activation space, the dogs changed the media clips or the dogs explored the device. As stated previously, more work would need to be done to explore this phenomenon further.

Whilst analysing the longest activations that the dogs had with DoggyVision whilst it was playing media clips, further evidence was presented that the two dogs behaved differently when interacting with the screen but did share similar behaviours of ear pricking and head movements. This brings researchers insight into how dogs use devices and shows that whilst the dogs were not always watching DoggyVision as it played media clips, their attention did flicker between the environment, other modalities and the DoggyVision screen. Whilst dog media devices like these have been suggested for use whilst a dog is alone, remarkably Dog A and B's longest activations was whilst they were with their owners.

The owners did not seem to notice a difference in their dogs' behaviours with the device other than seeing the dog attend to the screen whilst DoggyVision was playing media clips. Dog B was seen to growl at the screen giving indication to Dog B not liking the DoggyVision device. Both owners reported that the dog behaved with the device in a similar manner to a TV device. Dog B's owner did expect more growling behaviour, though, as he reported that the dog often growls, barks and approaches TV devices. Included within this dissemination, Dog A and Dog B overall preferred to watch nothing whilst the DoggyVision device was delivering media content. As discussed within ACI, this is not the first instance of ACI technology being rejected by animals (Ritvo & Allison, 2014; study two [Chapter 6]). During the International Animal Computer Interaction Conference 2016 (ACI2016), there were increasing questions around the benefit of such technology and the need for it to be explored first, such as done here, to give an insight into these spectacles. Whilst analysing these results, it did bring to question the definition of interactivity for dogs and whether interactive screen devices need to be watched to be interactive (as shown here through 'looking' and 'not looking' codes). In dog behaviour, it is often seen that owners will leave the radio on for dogs, particularly young dogs and those with anxiety issues (Takeuchi et al., 2000). In this instance, the dog could be attending to the device, just not visually.

Another query this research raises are the diffraction between the dogs' natural reflexes to the device turning on (sound and visual stimulus), such as ear pricking and the dogs own self-initiated behaviour. This initiated response aimed to be minimalised through the system's sound being not too loud, but its impact is unknown. This behavioural difference could be further considered by comparing the standard behaviour of the dog whilst watching TV to the DoggyVision device.

8.4.2 What Was Learned about the Method

The study defined here provides evidence that the method of an interactive dog screen device, DoggyVision, was effective at gathering useful results in a friendly manner. From exploring this method, it was found that dogs would often not stand still whilst interacting with the device. They would often move with quick body movements from their tail, run in and out of the activation space or have long periods within the space (sleeping) and generally behaving normally. There was no aggressive behaviour spotted towards the DoggyVision device, indicating that the dogs were comfortable with the DoggyVision device. It is therefore important to have the activation method fit around these normal dog behaviours. This user-centric design was implemented within this study by having the DoggyVision tracker at the dogs' body level to allow sleeping (laying down) in the area and the fast wags of a dogs tail and body movements allowed for within DoggyVision metrics. In this manner, the DoggyVision device formation was shaped around the dogs' normal behaviour.

The limitations of the method were mainly around the tracking of the dogs' entry and exit from the space, which had to be limited because of too much dog movement. Thus, the three-second counter was used during which time in and out movements were discounted. A more sophisticated detection system, such as face recognition as used in HCI as discussed in study 1 (Chapter 6), could be designed to allow more granularity of tracking whilst not crashing the system.

As used throughout this research, this method adhered to the principles outlined by Mancini et al. (2016) and the research philosophy (Chapter 3), to bring a dog-friendly method to the ACI community. This stance of allowing exploration of a device from a dog's perspective, designing for the dog's interaction style and then from the results given by the dog further developing the device is what forms the basis of dog-friendly research. Whilst the dogs involved within this study did both behave differently; these findings begin laying the foundation for the ACI community bringing valuable initial results and encompassed method.

8.5 Conclusion and Future Work

Within this work, we aimed to determine if dogs could use an interactive media device, DoggyVision, within home environments and to explore both the method and usage in a dog-friendly ethological manner. In the case of the first question, the research study shows insights that this was achieved through the DoggyVision system being both noticed and used by the dogs with an increase seen in watching behaviours of the screen. To bring more formidable results, this method and the DoggyVision system needs to be tested with more dogs. It is accepted that this work has limited participants but provides a further step and method working towards dog-initiated screen devices.

These insights brought by the study would benefit those seeking to develop dog interactive media products and those working in ACI with screen devices. The findings confirmed that the dogs did look at the developed DoggyVision device having varying activations over the days with no noticeable pattern, increased their watching behaviour with the device and either did not mind the device or avoided the activation space.

The work here builds on previously seen behaviours by dogs with media systems, gradually building a set of friendly dog interaction methods to ACI. As previously mentioned, this could be further continually developed and tested with more dogs or further explored in-depth through further recorded video encoding to bring more conclusive results. The recorded videos collected from DoggyVision have also only been coded for 'looking' and 'not looking' but could also be coded for other behaviours, such as the direction the dog enters the space, head-to-body relation and the dog's activity whilst the device is active bringing more meaning to the current results.

Another interesting divergence would be to test DoggyVision with a different activation method other than proximity, such as tactile devices or changing the screen to an on-the-floor projected interactive system. As screen devices evolve, with virtual reality becoming a possibility for dogs through visual interface screens (Ohta et al., 2016) and TV viewing changing over the years (Wheatley et al., 2014), this method could also be used with different screens. In this manner, this method brings to ACI a methodological way of investigating animal-screen activation from an ethogram standpoint.

This method presents the first specially made dog media playback device that seeks to both track and monitor the dogs' activations. The behaviour noted by the dog is seen to make suggestions towards aiming DCI technology at their behavioural requirements. Maybe in this way, this chapter highlights a need in DCI to think about how we design tracking devices for dogs. Through this study, a corpus of dog movements has been built up with an interactive screen device and would be ideal to train a tracking device towards this seen behaviour. As both dogs behaved differently, these devices could potentially be adjusted for each dog. This suggests that for the future of DCI, a standard tracking device could be implemented to learn and then individualised to adjust to the dog.

In conclusion, a device put into a dog's home allowing a dog to initiate their owner media activation testing viewing habits between an on and off state has been presented: DoggyVision. The findings provide evidence that when a dog is presented with an automated DoggyVision device, they will attend to the device through an increase seen in looking behaviours. Overall, even though the device was designed specifically for dogs, the dogs, when confronted with the device for a longitudinal period, either behaved similarly or avoided the device preferring to watch nothing; both behaved differently. The important findings of this study, however, is that this method gives an indication into a dog's usage of an UI through captured videos presenting both ACI and HCI methods of quantifying interactivity with nonverbal users.

The work within this study highlights the importance of exploring devices with dogs through an ethogram. This work adheres the technology towards the end user's requirements in a dog-centric manner following guidelines laid out within this thesis of Dogs Attending to Screens and Media (Section 3.2.2). It is through this stance of continual research and development within ACI in an animal-friendly manner that the results can be shaped around the animals' findings, by allowing the animal to explore technology drawing at the unaltered root of a voiceless user truly centring the practice.

8.5.1 Method Cost

The method presented above does come with a certain cost at the expense of both the research data and the researcher. The major cost involved is time, both through the longitudinal study and the analysing factors. Within this study, one week of data gathering was used, as it allowed the mitigating factors of the owner's normal routine to be discounted (i.e., weekend home with dog vs. weekly workdays). Because of the high number of video recordings captured, there was also the cost towards the researcher of individually analysing every recorded video to clean, code and then analyse the behaviour; each recorded video took approximately 20 seconds to analyse for one behaviour. The advantage to doing this 'by hand' was that the researcher was able to gather an in-depth picture of the activations thus learning much about the dogs' general behaviours with TV devices. For UX designers, this recorded video-watching insight itself might hold more value than the numerical activation data, particularly the long period of data.

Alternatively, a cut-price version of this method could also be implemented over a period of a day, as long as the researcher ensures that over the two periods captured, the dog and the owner has the same daily activities. These restrictions are necessary, as the owner, other humans and/or animals and the daily routine can cause a confounding variable influencing the gathered results.

8.5.2 Conclusion

In summary, this chapter has three contributions towards the HCI, ACI and media entertainment community: a way of tracking dogs to enable a device to turn on and off (DoggyVision tracking), from this the mechanisation of playing media clips when a dog is detected (DoggyVision media delivery) whilst recording this activation and lastly the method of monitoring activations with nonhuman users creating a baseline of data and then presenting the device. The novelty within this work is the embedded approach of capturing data itself providing useful information through the DoggyVision device and software.

These contributions, whilst being pertinent to the design of interactive technology for dogs, introduce more guidelines for researchers with dogs through the presented method and ethics of working with dogs and TV technologies.

This study concludes the last study done within the body of this thesis, built upon previous gained knowledge through the studies and method findings within the dog-centric stance resulting in various methods and from these results brought to DCI. Within this chapter specifically, a dog-driven device was made to allow the dog to have a more active role within the system and test how dogs use devices like these within the first dog-driven media delivery system.

8.6 Contributions Derived from the Study

- A device was built to allow a dog to initiate playing media using proximity tracking called DoggyVision.
- A method was devised to both control DoggyVision system playing media to the dog, film the dog whilst he was within the tracking area and then record this data using technology.
- A method of baseline data to test attention with and without the screen device (week 1 vs. week 2) has been successfully used with dogs.
- Initial results show that confronted with an interaction media device, dogs either keep at a normal or activate the device less with the device.
- Both dogs interacted through activations with the device differently, leading to potential research area for dog screen tracking devices to adapt to the dog’s behaviour.

Chapter 9

Conclusion

9.1 Introduction

This chapter summarises this thesis by revisiting the research questions initially laid out (Section 9.1.1), re-stating the contributions made (Section 9.2) summarising the limitations of the work (Section 9.3) and highlighting future research opportunities (Section 9.4). The contributions of this thesis are explored through the design of screen media for dogs in the empirical findings (Section 9.2.1) and the methods formed to capture and quantify a dog's attention to screens (Section 9.2.2). This is followed by a critical review of the principles adhered to within this thesis when working with dogs in DCI (Section 9.2.3). Following this review, contributions are given to both the ACI and DCI communities (Section 9.2.4). This chapter, and thesis, then concludes with some personal thoughts upon the subject topic (Section 9.5).

9.1.1 Research Questions and Aims

The two main themes throughout this research were *investigating how dogs attend to screen technology* and *investigating how to capture this attending behaviour methodologically in a dog-centric fashion* (Section 1.1). The primary aim of this research was to investigate in an ethological manner a dog's interaction with media screen technology through four questions (Section 1.6):

1. Can methods that can capture a dog's attention to single, multiple and dog-activated screens be developed in a dog-centric manner?
2. When different media are presented to dogs, do they show preferences, and do they follow preferred media as they move from one screen to another?
3. In what ways can a dog's attention to screens be quantified in a useful way from an owner's, a computer's and a researcher's standpoint?
4. What effect does taking a dog-centric philosophy have on the study of dog-computer interaction?

These questions were asked to support the research objective which was to investigate methods to study dogs attending to screen interfaces.

In the case of the first question, the three studies presented built upon each other to develop a growing set of methods to capture a dog's attention. This began by presenting a way of automating the dogs' attentive behaviour using image recognition in study 1. This was found to be difficult to do, in a dog-centric way, within the current confounds of diverging dog physiology and within the timescales of the thesis work. Drawing from these results the second study moved towards building a 'lower-cost' method of using multiple cameras to capture a dog's attention whilst viewing multiple screens. This method was dog-centric as it allowed the dog to behave normally without training and allowing some level of dog consent. The last study, study three, then took this idea of using a camera to record the dogs' attentive behaviour further by developing a prototype system that could be initiated by the dog themselves thus stepping away from the human driven systems. These studies therefore showed that it is possible to capture a dog's attention using both cameras and image recognition on a multitude of screens within a dog-centric stance.

The second question, of a dog's preference, built on previous research and literature and was primarily investigated in study two. This study demonstrated that the dogs used within the research behaved differently towards multiple screen devices but did align with previous research of preferring dog oriented videos which was then reflected through the media choice in study three. As this study was the first of its kind, the findings also presented evidence that dogs within this study did not follow media between screens which perhaps says something about the level of attention to the media in so far as if it had been especially captivating to the dog then one might have assumed that it would have been followed.

The attentive behaviour displayed by the dogs needed a way to be measured, as posed in question three. From an owner's perspective, tool 2 provided a way to facilitate and potentially enhance an owners' interpretation of a dog's behaviour through an informed observer stance. Using technology, study one provided a way of determining the dog's head direction automatically (left, centre and right) but this was costly to code. Study two demonstrated a way of quantifying a dog's looking behaviour between multiple screens by correlating multiple camera and researcher observations. The effort needed in this set up was still considerable as video had to be watched and coded but this was less costly than image recognition. This method was then used and taken further in study three with the analysis of 'Looking' and 'Not Looking' providing a way to measure a dog's observing behaviour.

During the design process for these methods the research stance was to centre the interaction around the dog users. Research question (four) asked about the effect this philosophical approach had upon the outcomes derived. As study one showed, applying a dog-centric stance made the automatic tracking of a dog's attention with screens difficult as the dog could not be trained or forced to wear computer machinery. The approach of using cameras, whilst dog centric, did not allow for the granularity that eye and head tracking gives, but did allow the dog to behave normally. A benefit of this philosophical stance was that it exposed results around non-viewing that have not been seen before in ACI by allowing the dogs a form of consent to not view the screens. As study two and study three show, when confronted with a screen device(s) dogs spend most of their time not viewing media being played to them, behaving differently either preferring to play with their owner, the researcher, toys or simply doing other behaviours. It is in this way that it was found that the dog-centric philosophy taken does mitigate the results, but allows for more natural behaviour and thus more real-world findings.

The aims of the research were

1. to see how dogs interact with media technology over screen systems and to design methods of tracking and mechanisation, thus their use, of screen technology,

2. to develop methods and theories to aid the design of screen technology with dogs in an animal-centric fashion and *adding to the existing DCI community base of knowledge, and*

3. to investigate a dog's attention to screens and identify future research directions for dog media technology (Section 1.5).

Aim one was met having primarily been investigated over the three studies which were iteratively designed taking from each other's findings to lead towards a method of tracking and mechanising a screen system based upon a dogs' requirements (DoggyVision). The dogs' behaviour towards screen devices, such as an average of three second attentions (study two), averaging out results for a dog's philology (tail wags) and the detection being at a dog's body height (study three) were findings which were then implemented into the method design for tracking and mechanising the screen. These findings help build up a picture for other DCI researchers and system designers of how to build interactive tracking screen devices for dogs. As this thesis demonstrates, image recognition and cameras can be used for recognition and proximity tracking can be used as a mechanisation for screen technology.

Aim two was met through the method formation in the three studies and their embodied philosophic theory on dog-centered screen machinery. This theory was situated within investigating where the centre of the design was and was instantiated by providing tools (tool one) to give designers initial guidelines through personas in which to design dog centered devices adding towards the tool base of the DCI community. The two tools delivered complement each other for the DCI field by providing a way of modelling the user during the primary design phase (tool one) and then aiding towards quantifying the dogs interactions (tool two) with the methods to capture the dogs attention held within the studies themselves.

The overall thesis reaches towards aim three through its findings and method formations giving future directions for DCI and ACI researchers. As tool one suggests, a future direction for ACI could be to take further methods from Human Computer Interaction (HCI) and build up a picture of dog users to centre the design both initially and more appropriately. Tool two, also taking from HCI, suggests that for the future of DCI methods can be developed to not only enhance the feedback from the dog themselves, but also the interpretation from the dog owners. Study one provided a way of automatically tracking the dogs head movements giving indication towards further developing a system like this for DCI and suggesting infrared as a future technique. Study two also provided a method of capturing a dog's attention between screens signifying for further work to be done in this area and indicating single screen use for DCI. Lastly, study three provided a method for dog initiated media watching using proximity tracking suggesting for future work the idea of a baseline data to provide means of investigating behavioural change caused by machines used at home.

The author considers that the aims and objectives laid out were met, with a discussion held around the major findings and contributions in Section 9.2.

Throughout this thesis, methods were brought together from the vast knowledge in HCI, the subfield of child-computer interaction (CCI), ACI and animal behaviour, to link together the known information and methods (Table 24).

Study	Method Description	Discipline Originated From
Tool One	Using the personas method	Human-computer interaction (HCI)
	Classifying a dog using their statistics	Animal science
Tool Two	Designing an information sheet on dog behaviour	Animal behaviour
	Creating an informed observer	Child-computer interaction (CCI)
Study One	Classifying and processing images to ascertain their content	Computer vision
Study Two	Filming a study and analysing the video later	Human-computer interaction (HCI)
	Assessing and noting the dogs' behaviour during the study	Animal behaviour
Study Three	Proximity tracking	Human-computer interaction (HCI)
	Assessing and noting the dogs' behaviour	Animal behaviour
	Filming a study and analysing the video later	Human-computer interaction (HCI)

Table 24. Origination of methods used within the studies and theories within this thesis

This interdisciplinary research approach is one often seen in ACI and within this body of work as it helps to develop methods to monitor a dog's attention and behaviour, whilst also gathering initial data on how dogs attend to screens, developing ethical and philosophical principles on dog-centric research. This aids in building up foundational guidelines for DCI whilst testing the known knowledge in more developed fields.

9.2 Discussion and Contributions

The thesis is that *Dog-Centric Methods and Tools can be developed to study how dogs interact with screen technology* and the major contribution is the empirical work that supports the claims made. Contributions include the findings from the empirical work, the methods employed and tested and the philosophical and ethical stance used.

These contributions are explored below through the design of screen media for dogs (Section 9.2.1), methods to study a dog's attention to screens (Section 9.2.2), principles for working with dogs (Section 9.2.3), contributions to the ACI community for DCI design (Section 9.2.4) and overall scholarly contributions (9.2.5). These findings are from the two tools developed and the three studies conducted:

- **Tool One:** Animal Personas: Representing Dog Stakeholders in Interaction
- **Tool Two:** Using Behavioural Information to Assist in the Evaluation of Dogs Responses to Media: Dog Information Sheet (DISH)
- **Study One:** Tracking Dog's Head Movements
- **Study Two:** Dogs Interactions with Media: Dog Centered Approach to see the Interactions Between Screens
- **Study Three:** DoggyVision: Examining How Dogs Interact with Media Using Proximity Tracking

9.2.1 Design of Screen Media for Dogs

This work provides initial empirical findings for the DCI field and for dog-computer product developers on several key aspects of how dogs attend to screen devices.

Study 1 was the first to consider how a dog attended to a screen. The main aim of this study was to classify the dogs' watching behaviour with the method being used, of filming Dog A in various head positions, and from this taking the image frames for classification to allow video analysis. This study built upon Somppi et al. (2012) and Williams et al. (2011)'s work to move away from trained or forced viewing to contribute a new method of tracking a dog's attention with screens in a friendly dog-centric manner by using image recognition. Whilst this was not the first image recognition method to be used with animals (Pons et al., 2015) or dogs (Mealin et al.,2016) this did provide an impetus that image recognition can be used within the study area of dogs to classify their behaviour with screen devices.

Drawing from the complexities faced within study one, study two investigated classifying a dog's attention through recorded data. Study 2 was with two dogs—Dog A was the same dog as in study 1, and Dog B was introduced. This study sought to bring the dog-screen field in DCI forward by bringing a way to investigate a dog's interactions with screens building on previous tracking studies conducted by Somppi et al. (2012) and Williams et al. (2011) but within the knowledge gap of a dog-centric manner.

This study investigated the unknown area of multiple screen use by dogs showing that the dogs did not follow media content between screens but instead favoured a screen position, indicating that multiple screens had little impact on the dogs' viewing habits. Crucially that dogs did not follow media clips from screen to screen suggests that their attention is not strong to a story in media. This study also found that the dogs appeared to have longer viewing times and longer mean interactions (Table 17) with dog videos as opposed to videos with other content; this confirms previous research (Somppi et al., 2012) building upon current knowledge. When a dog did attend to the screen, it was found that the attention period was typically very short—an average of less than three seconds (Table 25; Table 17) bringing new insight into DCI of dog interaction timing with screens. Drawing from these results of dogs having low attention periods, a minimum interaction timer was implemented in study three where once again low timings of interaction were seen. As these studies allude, there was possibly an age effect for the time on task where the younger dog spent less time attending to the screens in study two.

Building from this study, study three sought to further centre the interaction through allowing the dog to control the activation of a screen device playing media, on a single screen taking from study two's findings. Study three found that Dog B activated the DoggyVision devices less over the two weeks with Dog A keeping the same number of activations. This study showed that the two dogs interacted with the device differently, as previously seen in study two, but that these differences aligned with the findings from tool one of building dog personas. In the creation of personas in tool one, a key observation was the variability of dogs between breeds, ages and home locations. In this way, this contribution builds upon previous findings of dogs being shown to have personality traits (Albuquerque et al., 2016) into technology instances where the dogs' personalities and age could directly affect the interaction undertaken in DCI situations.

The main findings across the studies are captured in Table 25, showing the two dogs and their behaviours across the work. The modal number is rounded to the nearest one decimal point with figures from study 5 coming from week 2 when the DoggyVision device was turned on.

	Dog A		**Dog B**	
	Study 2	**Study 3**	**Study 2**	**Study 3**
Maximum attention (Seconds)	18.1	54.27	10.8	108.5
Modal attention length (Seconds)	2.4	3.14	0.5, 0.6	3.14
Mean attention (Seconds)	3.3	3.14	1.3	3.14

Table 25. Dog A's and Dog B's attention across studies 2 and 3.

As Table 25 shows, the dogs did not seem to attend much to screens, having very low attention times, preferring to watch nothing and either avoiding or maintaining the same level of attention when using the dog-initiated screen system that played media. These results contrast against previously seen results in animal cognition (Sompii et al., 2012; Williams et al., 2011) as the method employed allowed the dogs a form of consent (Mancini, 2011) of being able to walk and look away from the screen bringing in the new variable of unwatched data. The total duration of time spent not watching screens was much more than the total time spent on task but the method used will have resulted in a reduction of tracking accuracy when compared with previous visual perception research in more controlled settings.

Averagely, the dogs seemed to have a three-second or under period of attention with screens, which was seen to slightly vary across video content. The 1.84-second increase for Dog B in study three is thought to be due to the minimum time of 3.14 being introduced. Interestingly, as shown in Table 25, the mean attention was often higher than the modal number due to the few instances of the dogs having long interactions as shown through the maximum attention being a considerably higher number. As this work was the first to investigate a dog's timings with screens, this provides a baseline for future DCI screen designers to implement minimum and maximum screen attention, as done in study three, based upon these findings. In this way, one of the scholarly contributions to draw from this thesis is that dogs averagely have low attention times towards screens and thus such technology should be designed accordingly.

Videos that got normally attended to more by the dogs within study two were those that had mainly dog content aligning with previous research (Somppi et al., 2012). Study two, three and tool one, highlighted the differences between dogs, as noted in age, breed and location, both in initial requirements and in their attention to screen technology.

9.2.1.1 Findings for Designers of DCI with Screens and Media

The main finding from a design perspective is that dogs do not attend to the screens for long periods, as shown through the repeatedly short attentive looks. There are instances of prolonged attention from the dogs, but these are minimal. Thus, short media clips should be used with dog media devices. Ideally, dog media systems would be designed to allow for this change in attention between short and long periods to allow for uninterrupted viewing.

9.2.2 Methods to Study a Dog's Attention to Screens

In the early stages of this research, whilst dogs had been using technology for some time, ACI as a field was, and largely is, still taking shape with a range of field norms, ethics and methods used for various projects (Mancini, 2011; Mancini et al., 2012; Mancini., 2013). One aim of this thesis was to explore methods, based on the encompassed ethical and philosophical principles, looking further into the fourth agenda of HCI-to-ACI transference mentioned within the ACI Manifesto (Mancini, 2011). The methods used within this thesis present ACI ways of capturing data from untrained dogs in respect to their attention to screens in a dog-centric manner. These methods encompass the dog's owner, the researcher and the dogs involved within this research. Before this investigation, the cited work within the field was, and largely still is, held mainly around a dog's trained behaviour with a screen device (Zeagler et al., 2016; Sompii et al., 2012; Williams et al., 2011), with very few studies investigating the dogs' ordinary (untrained) interactions (Baskin & Zamansky., 2015). The work reported in this thesis has provided some insights into new methods that can be used with dogs in an untrained dog-centric manner.

The first study found that it is possible to use computer image recognition software (MATLAB) as a method to investigate a dog's head position with an above 82% success rate. This indicated the possibility of the identification of a dog's head position to be moved away from the human researcher in some sense to an automated system. Since this study was conducted other researchers have taken this work further in dogs

(Mealin et al., 2015; Mealin et al., 2016) to allow movement recognition at both a head and body level. This movement away from human intervention was also explored using the method of proximity tracking taking from ethology (Heupel et al., 2006) in the third study to enable the dog to turn on and off the screen device. This method of proximity to define a trackable space which turns on a screen device with the dog's presence allowed the dog to watch the screen and was the first to be used in animal technology instances in ACI. The dogs were able to notice the technology as seen through an increase in looking behaviours towards the device in study three between week 1 (device off) and week 2 (device on) providing an impetus for these methods used in ACI.

The second study builds upon the previously found method of quantifying a dog's attention through video cameras, as used in ethology and in the authors previous work, by combining manual timing of these interactions whilst also recording the dog's behaviour. This videoing of behaviour for later analysis was used throughout the studies as a viable method of capturing a user's behaviour. In study two it was found that multiple cameras behind and in front of the dog aided in the researchers' analysis of attending behaviour. As evident from the captured data, this new method provides a way of capturing a dog's attention with screens, and multiple screens, within the dog-centric principles.

Videoed and researcher opinion were not the only methods used for data capture within these studies, as often the dog's owner would also be included and asked to comment. Tool one and two, taken from HCI to the field of ACI, focus on not only empowering the dog through centric systems but also educating the human involved in an HCI manner, investigated here through both creating an informed dog owner and aiding the researcher during the initial design phases using personas.

Tool two took the CCI method of using an adult as an informed observer for children and technology (Donker & Reitsma, 2004) into the field of ACI for a dog and their owner. Whilst ACI has repeatedly used an animal's carer as a usability expert (Baskin & Zamansky., 2015; Ritvo & Allison., 2014), this was the first study in ACI to seek ways to enhance this data collection method. As tool two demonstrated, creating an informed dog owner has been shown to gather more interpretive information on dogs' behaviour whilst dogs are using screen devices by 30%. This enabled further behaviours to be encoded and found, providing an enhanced method of behavioural analysis of their dogs from the owner's perspective enhancing an ACI method.

Personas have been commended by ACI researchers to help aid ACI designers in the initial stages, where in a field, the end-user and ethnographic information is not always available. Examples have previously included assistant dogs (Robinson et al., 2014) and chickens (Frawley & Dyson, 2014). These personas provide valuable data and methods for researchers to model their end users and provide methods of correlating behaviours. Tool one builds upon these two instances in ACI drawing from HCI to provide a method of building personas for DCI researchers using the HCI methods of questionnaires and then word and phrase analysis to build useful role-based personas specifically aimed at screen devices. Tool one additionally presents a data storehouse of 196 dogs as reported by their owners derived from questions over their basic stats and interactions with technology from a screen media perspective. From this data storehouse, six role-based personas are developed over varying breeds, ages and home locations to aid in the initial stages of designing methods and technologies for dogs attending to media.

To conclude, this thesis presented methods on both capturing and quantifying a dog's attention to single and multiple screens using both high-tech image processing and low-tech video solutions. These methods are then further supported through aiding the owner's evaluation of their dogs' behaviours and supporting the initial designs of dog screen systems through typical user representations.

9.2.2.1 Optimal Dog-Centric Research Environment

Within this thesis, conducting research with dogs has been explored in order to better understand how to create an optimal research environment for dog-centric studies. Interestingly, the methods used within the studies had granularities between the human involvement and the dogs' autonomy in data gathering (Figure 55). These studies aimed to delineate a step away from the human involvement more towards dog autonomy to centre the research environment.

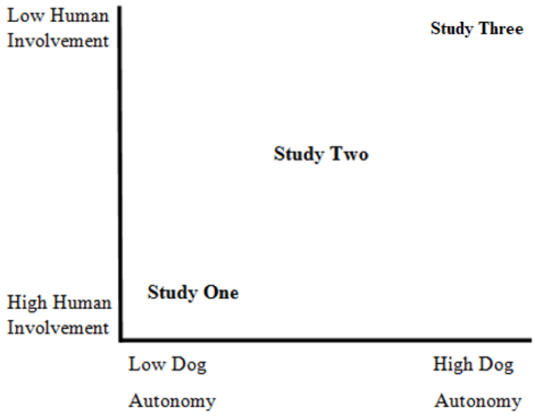


Figure 55. Granularities in the conducted studies (1,2 & 3) between the dog's autonomy and the human involvement during data gathering DCI studies.

Within study one, the dog had low autonomy; Dog A was required to follow a presented treat so images could be captured. There was a high level of human involvement through the data gathering and in manipulating and recording the dog. In the second study, the dogs had a reasonable amount of autonomy as they could walk around the room and choose to look at the screen or not, drawing from Mancini (2011) notion of consent. The human involvement within study two was less than in study one, as the dogs were left to their own devices, but there was still a human element through recording the study, and in noting behaviour at the time of data gathering. In the final study, study three, the dogs were given high autonomy as they had total freedom to walk away from the device and out of the room as they pleased with no need for the human involvement at the point of data gathering as the system recorded this data. In this way, the studies within this thesis worked towards becoming more dog-centric and less human-centric during the data collection stages by both reducing the human's involvement and allowing the dogs further autonomy.

The methods of the studies (1, 2 and 3) were also built upon through their level of description, understanding and knowledge of the effects happening to the dog. Within study one, there was little knowledge of what the dog was doing other than a description of what was happening as the only data being gathered was the dog's head movements. This was built upon in study two, where the method allowed for a description of where the dog was looking and the known behaviours around the dog's choice of attentive behaviour such as their ear and head movements. Within this study though, there was still not an understanding of the effect that these screens had upon the dog. It was this attribute, of understanding the effect, that was built upon in study three, where there was a baseline of behaviours introduced (week 1 vs. week 2), allowing a level of interpretation towards the effect the screens were having upon the dogs. This, along with the description of dog behaviours and the proximity data being gathered, allowed for a progressive approach to DCI throughout the studies.

Thus, these studies, conducted within this narrative, built towards further methods of data gathering and becoming more dog-centric through reducing the humans' interpretation and increasing the dogs' autonomy in data collection and advancing the methods to allow for further data to be gathered.

These findings lead towards indications for the optimal dog environment for dog-centric research. These optimal settings are that research is to be done within the dog's own home with the owners involved at some point to assist in interpretation, as done in this study with DISH (tool two). An information sheet within this narrative helped the researchers to understand the dogs' motivations more from the owners' perspective. The owners' involvement was also used to help understand the dogs initially, as seen through initially asking questions on behavioural disorders. Ideally, the image classification schema would allow for a fine-grained analysis, taking away from the humans' interpretation, but the human is still important within the study space as the videos often require human classification to clean the data. In this way, the human researcher and the dog owner are still significant. Lastly, in the ideal situation on studying a dog's attention, a baseline would be used without any studied media to allow for an understanding to be derived upon the effect the screens are having upon the dog.

9.2.3 Principles for Working with Pet Dogs in ACI Research

Throughout this thesis, different approaches have been used with dogs. The underlying themes of these methods are the principles for dog and screen interactions with media (Section 3.2.2) and the associated philosophical stance of dog-centric methods (Chapter 3). This section of the thesis reflects on how this positioning affected the research and draws up a new revised set of principles.

The eight principles given earlier (Section 3.2.2) were used throughout the research. The first principle of the guidelines for dogs and screen interactions with media was to allow the dog to walk away from the study as a low-level form of consent. This associated tightly with principle 8: not training the dog to attend to systems. These principles were most influential during study 2 (Chapter 7) and study 3 (Chapter 8) as they allowed the dog to not attend to the media being played on the screens and to walk away from the study. In a positive way, these principles allowed this non-attentive behaviour to become a result that would not be available if the dog had been more constrained to the screen opening up a new space of research away from trained responses as in (Sompii et al., 2012; Williams et al., 2011). The downside of this method was that there were gaps within the data, as seen in study 2 (Table 17), where there was no screen being watched as the dog walked away from the study. Additionally, the amount of time needed for the studies was considerably extended as much of the time there was little going on. This is evident in Table 26, which shows for both dogs, A and B, most of the time was spent not watching the screen.

	Dog A		Dog B	
	Looking at Screen	**Not Looking at Screen**	**Looking at Screen**	**Not Looking at Screen**
Study 1	48%	52%	28.6%	71.4%
Study 3	31.8%	68.2%	32.3%	67.7%

Table 26. Dog A's and Dog B's percentages of looking behaviour vs. not looking across studies 2 and 5

It can be argued that principle 1 drove the researcher to implement and install the DoggyVision system used in study three as it became apparent that considerable time was needed in order to examine interactions. The baseline measurements used in this study also showed that it was important to understand the underlying activity levels of a dog to interpret the logged interactions.

Principle 2, the usage of familiar items, was used in study one (Chapter 6) and study two (Chapter 7), as can be seen by dog toys and blankets in the study space (Figure 41). There were instances where the dogs involved in these two studies would often prefer to play with their toys, or sleep on their blankets, rather than take part within the research, reducing the results gathered. Whilst this was not explicitly measured in these studies, a researcher estimate is that it accounted for between 10% and 20% of research time for Dog A in study 1, between 20% and 25% research time for Dog A in study 2 and between 20% and 30% research time for Dog B in study 2. This playful and resting behaviour, however, was used as an indicator that the dog felt comfortable within the environment, but it certainly did introduce distractions. In study three, there were distracting objects in the room as this was a home familiar to both dogs, but, as can be seen in the summary data in Chapter 8 and Table 25 above, the mean time attending to the screens was not much altered. Thus, it can be hypothesised that the toys, or the home, or the ability to walk away does not differently impact on the results. The mean time for Dog B within Table 25 is thought to be higher as the DoggyVision device only allowed to be an iteration of 3.14 seconds.

Principle 3, working within the dog's home, was not always possible within the studies. Due to the technology needed in study 1 (Chapter 6) and study 2 (Chapter 7), the dog had to be within a lab environment. In these cases, the principle of familiar items (2) was used to simulate, as much as possible, a home environment. In seeking to enact the principle in the third study (Chapter 8), there was an effect on the range of possibilities as it was extremely difficult to recruit participants who were willing to allow the DoggyVision system into their homes, especially as it was filming for two weeks. As noted within studies 2 and 5, Dog A was the researcher's dog, and Dog B belonged to a member of the researcher's family. This principle does, however, allow for normal behaviour, as seen in the third study (Chapter 8), where the dog would sleep, play with toys and their owner, run and behave normally.

Principle 4, having the owner or carer observing, was interesting as in the first study (Chapter 6), this was not needed as the technology conducted the interpretation, whereas on the other end of the scale in tool two (Chapter 5), this was primarily concerned with owner interpretation of their dog's behaviour. Whilst this principle provided a safeguard for the dog through their owner, it did allow for a deeper look into the data gathered in study three (Chapter 8), where the owners commented upon their dog's behaviour.

Principle 5, never using distressing or familiar footage, was implemented through the different studies, with the obvious consequence being that distressing footage was never used. In a very simple way, this worked in so far as the research tried to establish what kind of media was good with dogs. This principle identified that dog howls can be triggering to some dogs in tool two and that dogs tend to attend to dog-based media more frequently than to other media in the second study. In this way, principle 5 allowed the shaping of the media content to iterate through studies to safeguard the dog.

Principle 6, screening for emotional behavioural problems with dogs, was used throughout this research and became important within study three (Chapter 8), where dog owners with separation anxiety would often want to have a media playing system in their house as a method of reducing this negative behaviour. This principle did reduce the dogs available for studies in this way but did ensure the welfare of the dogs involved. Principle 7, testing methods and devices prior to implementation, was primarily used in the first study (Chapter 6) to test human eye and gaze trackers and the last study (Chapter 8) to provide usability testing of the device. Particularly within the last study, this allowed the system implemented to be shaped around the dog's normal behaviours, as seen within that study, with a delay being implemented due to the dog's fast tail wagging. In this way, this principle helped refine the method of capturing a dog's attention before the study, thereby improving the validity of the study.

From a scientific standpoint, these principles both hindered data collection through missing gaps of data and the dog not taking part within the study and ensured the welfare of the dog throughout. This allowed for normal data collection, however, from the dog and improved the welfare through safeguarding the dog from perceived stressors. Thus, valuable data were unattainable through these gaps, but these gaps of data allowed a different sort of data (non-attendance) to be recorded. This created tension between data and the dog where the studies within this narrative were based around the dog, reinforcing the dog-centric practices. Because of this dog-centric philosophy, studies had to be conducted for longer periods, in a hard-to-attain location (dog's home) with fewer participants.

9.2.3.1 Dog-Centric Principles (DCP)

Based upon these reflections, a new set of five principles is iterated, building upon the previous ones, called *Dog-Centric Principles (DCP)*. These are as follows:

1. Allow for Walking-Away Behaviour and Avoid the Need to Train the Dog. If the researcher is seeking ordinary behaviour from the dog, the dog must be able to walk away from the study. This can be achieved by not training the dog to look at the screen and allowing for normal behaviour.

2. Provide Familiarity Away from the Home. If the study cannot be conducted within the owner's home, then a form of familiarity must be provided. This can be through blankets, bedding, toys and other items.

3. Interpret Behaviour through the Owner. If interpretation of behaviour is conducted within the study, then the researcher should aim to include the owner within the study.

4. Screen Dogs for Emotional Behavioural Problems. If dogs are included within the study directly through system use, then they should be screened for emotional behavioural issues through their owner to prevent any negative behaviour.

5. Pilot Research Systems and Media. If new systems or media are being used with dogs, these systems must first be piloted with a dog first to mitigate the risk and find out usability problems initially.

These new principles differ as it was found that often these principles are situational, used throughout these studies under certain circumstances. Thus, these principles are now further frameworked around the study's' variables. The original principles of training and walking away were merged as to allow for the 'walking away' behaviour, the dog had to be trained to not use the screen, and as such, these principles were indicative of each other.

9.2.4 Contributions to the Animal-Computer Interaction (ACI) Community for Dog-Computer Interaction (DCI) Design

In the process of the research, there were elements of design work being undertaken which were found to be useful to other researchers and organisations in ACI. For instance, the author was asked to be an expert researcher within the consumer sector to advise a dog company on the design of remote control devices for dogs. It is in this way that this thesis has contributions: for the wider community.

For the community of researchers working with dogs, this thesis offers a set of personas validated by other ACI, DCI and HCI researchers to enhance the initial stages of design. These personas (tool one) are supported by a data bank of 196 instances of dogs' information. This databank can be used by other ACI researchers to craft their own personas for specific occurrences, such as different breeds or dogs, or the method used in this thesis can be further built upon for other animals. The DISH (tool two) was shown to be a useful tool and was reflected upon to be felt as useful by owners to help them focus upon their dogs' behaviour. This tool could be transferable across to other animals to create informed observers of animal owners and carers in ACI.

To those working with animals and technology, this thesis provides encouraging results that data can be collected from an animal in an animal-centric stance through shaping the method and thus the data collection narrative to fit within the animal's own parameters. This shaping of methods is supported through the principles and optimal research methods presented in this thesis, which could be transferred through exploration as done within these studies.

9.2.4.1 Recommendations for Interaction Designers in Dog-Computer Interaction (DCI) for Animal-Computer Interaction (ACI)

For DCI researchers in ACI, there are two propositions within this thesis. The first is the suggestion to determine the pool of dogs that the research is considering before choosing a method and system to research with. This knowledge gathering is necessary to get to know your users. This can be done by using the personas here or making your own personas on the large dataset available. The second proposal is that if the research is using the dog owners, then they should be educated to observe the studies either through using tools like DISH or by the researchers making their own similar product. This education process helps in making the owner more focused and allows more useful information to be collected within the study to better understand the dog.

9.2.5 Contributions towards ACI Manifesto goals

This work, similarly to the ACI Manifesto (Mancini, 2011) aimed to expand the animals', in this case dogs, horizon of user-computer interaction research through here exploring methods and theories to capture a dog's attention towards screen devices. This thesis contribution of principles builds from Mancini's fourth research agenda of researching animal-centred design processes by taking from the knowledge in animal behaviour and HCI fields to help in really centering research conducted with dogs through the iterated principles for working with dogs. These principles provided within this thesis themselves echo out the ethical principles provided of attending to dogs needs in non-invasive methods allowing the dog to withdraw as a form of consent.

Correspondingly, this thesis primarily investigates methods under these principles (fourth agenda) to explore the fifth research agenda in the ACI Manifesto (Mancini, 2011) of both adaptation, such as the informed observer, and developing, such as is the case in DoggyVision, methods and design protocols for DCI. Chapter five also directly looked at modelling participatory design in DCI systems mentioned within this fifth agenda. Finally, this thesis provides ways of building, and the initial use of, empirical research with dogs allowing growth in the sixth research agenda to shape the beginning of models of DCI.

9.2.6 Overall Contributions

In summary, this thesis has three main contributions of the built method and how to quantify the data drawn, ways in which to implement these methods in a dog's home and the ethical and philosophical stance formed and used within the approach.

This thesis took a HCI and ethology standpoint into ACI drawing from, like Tattersall states (Hodgeboom, 2015) the differences between species within the method conception. These built methods, supported by the initial data findings, within this thesis form the largest contribution; through the two tools and the three studies. The focus of this work with dogs and screen devices builds upon the diverse visual tracking interfaces already present within animal behaviour (Somppi et al., 2012; Williams et al., 2011; Zeagler et al., 2016) to bring an animal centric stance stepping away from trained responses to quantifying and capturing a dogs' attention towards screens from both the dog, researcher and owner standpoint. This attention tracking through observations was conducted in a low fidelity manner, allowing the dog consent over using the device, bringing in both an animal centric method to capture a dogs interaction towards screens and the encompassed results. This contribution is beginning to bridge the gap between highly constrained technology (Somppi et al., 2012; Williams et al., 2011; Zeagler et al., 2016) and image recognition (North et al., 2015; Webber., 2016; Pons et al., 2015; Mealin et al., 2016) for observational data to draw meaningful results that is friendly towards the dog and methodologically appropriate. These methods also do not require trained behaviour situations as in most ACI (Manicni et al., 2106; Gergely et al., 2014). Part of this method contribution is also by providing a way of quantifying the data captures through observations supported within this thesis through both researcher, dog owner and image recognition analysis.

Encompassed within this user centric stance is the move within animal studies from lab environments towards home environments, mirroring the dogs societal shift from working dogs to pets, to begin collecting more natural data. This stance, like Resner (2001) flips the traditional paradigm of using technology to explore a dog's cognition and behaviour, to exploring ACI in an interaction design stance for a dogs welfare. As it stands, this embodied work, is one of a few within ACI research (Zamansky et al., 2016; Geurtsen et al., 2015) that explores dogs using technology for dogs within their own home grounding ACI roots into tangible methods to explore this use. This contribution has reflections out into the growing pet industry (toys such as PetCube, Cleverpet, PupPod and DogTV for instance) for home alone pets by providing a way to both implement and design technologies in this growing market.

This choice of exploring a dog's home setting to empower a dog's use of technology was done within an ethical stance reflected in this thesis through the principles that restrained this research stance. These principles, drawing from the ACI Manifesto (Mancini, 2011), Mancini's ethical work (Mancini, 2016) and 3Rs approach (Väätäjä & Personene, 2013) aimed to move forward the ACI field by bringing in protocols that were dog friendly and dog-centric being both morally and socially ethical and lawful. This ethical and philosophical stance reflected into the methods undertaken formed a contribution within themselves as a stance to underpin the method choices providing ACI ways of implementing dog-centric ethically appropriate research within the home.

9.3 Limitations of the Work

The unique approach taken through this thesis initially came from the author's own philosophy on creating more dog-friendly research in ACI (Chapter 3). This builds upon the ACI Manifesto (Mancini, 2011) to attain at the very foundation a dog's input into technology, simply put, to understand in some way the dog's thoughts and then to act on this stance in an open conversation led by the dogs themselves. Whilst the approach has been shown to gather useful results through the five studies, it did highlight the tension in gathering research results for the humans' and the dogs' requirements. This work was centred firmly around the dogs' own requirements. This often resulted in missing data gaps and iterations of technology to meet the dogs' normal behaviour where possible.

It is acknowledged that the experimental findings held within this body of work have been derived from a few studies on two dogs (Dog A and Dog B) and have only used one breed of dog. As outlined within the chapters themselves, these studies have demonstrated some key areas for future studies. The data gathered that was used to generate personas was of a very different nature. A main limitation in that case was that this data was only gathered from enthusiastic dog owners who were willing to complete the survey and that the data could not be checked against video of dogs.

Because of the limitations around sampling, the results presented within this work are not really able to be generalised from; rather, they are used to further the discussion around terminology, methods and philosophical and ethical issues around DCI.

Equally, whilst media clips were used with dogs, and their attention surrounding these investigated partially, it is unknown what aspect of the media the dog attended towards (i.e. colour/sound influences). It was noted throughout the studies certain sounds caught the dogs' attention, but this is not examined within the work.

9.4 Future Work

As this field is a new area of investigation, there is much further work that needs to be done to iteratively test some of the theories outlined within with a larger dataset: of varying dog breeds at different ages in different locations. The results gathered are placed within the time and context of the current technology, which with advancements, turning towards the pet field and computer interaction interfaces, a few of the obtained results may not hold relevance over time.

The findings that have been discussed within this thesis have been received with interest within the community and where presented; however, the acceptance of these views varies dependent upon the community's set paradigms. The ACI community embraces the dog-centric methods and results gathered as the philosophical approach fits within the community paradigms. To the HCI community, they embrace the recognition of method transferences, particularly between dogs, children and other non-verbal users to elicit new methods. To the animal research community, the dog-centric approach taken is often considered unnecessary; instead, training is preferred. Nevertheless, they find the initial results gathered useful. To dog owners and those who look after dogs, the potential of this work holds promise of entertainment and enrichment possibilities.

Considering these constraints noted within the work and the changes that could be made, the rest of this section sets out the research agenda for future work which would have implications towards each of the communities outlined above. This research agenda forms an important contribution of this thesis.

9.4.1 Dog-Driven Devices for Enrichment and Work

Within modern society, dogs often spend time alone. Devices that are designed for dogs using screens could potentially provide a usable platform in which to develop enrichment devices for these dogs. This is not to state that enrichment is a sole process; technology could align with the human-animal bond to enrich that play, and indeed work. One of the biggest growth areas of DCI is devices to support a dog's work, including screen devices (Zeagler et al., 2016). A future step could be taken in DCI to use the methods in this thesis to allow technology to be shaped around the dogs' affordances so that screen technology used for a dog's work will become more suitable, as has previously been investigated in button systems (Mancini et al., 2016).

9.4.2 Developing Methods to Design with Dogs

The key area that requires investigation in DCI is the development of further dog-centric methods where the dog is seen as an active end user rather than having passive involvement where the system is deemed suitable so long as it is usable. The DCI field is currently lacking methods, and by trialling and building on current methods, as presented in this thesis, systems designed for dogs can become further shaped around their requirements and their usability. In this way, finding constraints within DCI systems can help effectively model dogs within these systems.

9.4.3 Human-Computer Interaction (HCI) to Animal-Computer Interaction (ACI) Transference

As stated in the ACI Manifesto (Mancini, 2011) and by researchers in the field (Where HCI Meets ACI, 2016), there is a need in ACI to create transferable methods and ideas towards its parent field, HCI. The alignment of HCI to ACI has been continually documented throughout this thesis, with methods also borrowed from CCI, but there has yet to be a complementary process of feeding back methods from ACI to HCI. With HCI being a more established field, admittedly ACI has lessons to learn from HCI, but HCI could also learn from the methods in ACI for its non-verbal or limited cognitive users. For HCI methods to suit these non-human-computer interaction users, the methods often need to be altered, the same alteration that happened in HCI with 'extreme' human users. When this method alteration takes place, new knowledge is created that others can use, and the new methods are then developed which can be used with other humans and non-humans. Whilst methods have yet to be 'fed back' within this symbiotic relationship, these two fields could learn and, specifically, humans could learn from non-human-animal interactions with technology to influence the system, as mentioned previously with non-verbal users. In this way, this relationship could help strengthen the requirement gathering with users in HCI who may also be non-verbal users or have limited cognition. This would allow for better design frameworks to be built in both HCI and ACI, allowing for more inclusive technology overall. This method transferal needs to be more than what is simply done in HCI, but with an understanding of animal affordances, growing both animal science and ACI in a two-way relationship. It is through this way that HCI can inform ACI, and the smaller subfield of DCI, leading back into ACI and HCI literately.

For the future of ACI in a mutual relationship with HCI, there are some interesting research questions and topics. Firstly, in regard to interchangeable methods, what are the key theories and methods that are compatible for this transference? Secondly, what can HCI learn from ACI and vice versa? By conducting research into this area, it helps to map the overlying transference aptitude of the two fields. Lastly, what use do these two fields have to each other; are there certain scenarios or methods that are especially useful in HCI from ACI or HCI to ACI? These are all questions that remain unanswered but will help conjoin the field growth, strengthening the work both held within this thesis through a shared knowledge and the field of HCI and ACI.

Mirroring the content of this thesis, which draws from HCI into ACI and then DCI, it would be interesting to take this back into HCI methods to map the transferability of the work held within. In this way, this thesis has implications mostly in DCI and ACI, but also for HCI.

9.4.4 Investigating What Is Interactivity in Dog-Computer Interaction (DCI)

At the beginning of this thesis, comments were given on the feedback loop between dogs and systems. One of the key areas for DCI is to investigate what it means to have interaction between dogs and technology. This can be done by further investigating a dog's attention towards technology to investigate a dog's reaction, bringing more formidable results to draw from. Currently, little is known about dogs' interactions with technology (the gulf of execution) and what the term 'interaction' means in the field of ACI. This could be further investigated through looking at what a dog's usability is through their attention and behaviour using systems and then aligning systems to allow for these actions. This could help further build up a stronger picture of interactivity in DCI.

9.4.5 Investigating Modalities in Dog-Computer Interaction (DCI)

Within this thesis, the human has been excluded where possible as part of the method approach where the dog is the sole user of the screen device. A point of interest would be to investigate if a dog's attentive behaviour dynamic with the screen would change if the owner was also to watch the screen with the dog. The way dogs ordinarily view screen devices is with their owner, so the next logical step upon this exploration points to investigating this occurrence.

Another possible research area, which was not approached in this thesis, would be to investigate the effect that noise and other media instances had upon the dogs' attentive behaviour. This could be done by leaving the television on permanently, or when the dog was within the home, to see what within the media attracted the dog's attention towards the device.

9.4.6 Moving Beyond the Human-Animal-Computer Void

As suggestion in Weirmen & Juhlin (2011) and in the literature review of this thesis, there is a need to move ACI research from a sole animal-computer interaction and human-animal computer mediated interaction towards animal-animal interaction. Perhaps this is the next step for animal-centricity by allowing an internet of animals to evolve allowing, in some sense, the barriers put up by humans to be surpassed. This narration includes multispecies computer mediated interaction. Whilst it is understood that currently the human-animal ACI user space has not yet fully been explored, this is not necessarily a prerequisite to animal-animal exploration but is sure to benefit the diverse multispecies use.

9.5 Concluding Remarks

When this thesis began, there was very little knowledge around dogs' screen interaction with media and within ACI research itself. Throughout the duration of this thesis, the community has grown, and new research has been presented, with the annual International Conference on Animal-Computer Interaction being in its fourth year with individual research communities being built and research increasing. The research within this thesis has already been heavily cited within ACI helping to play a part in this process, and it is hoped that it will continue to do so.

The technology available has also developed over the last four years, with drones and virtual reality becoming mass market consumables and tablet technology more frequently found within homes. In this way, the screens used for interaction are also advancing away from the monitor into immersible environments. These environments bring more possibilities for dogs away from the traditional screen interaction into more tangible created environments. Indeed, Ohta et al. (2016) aims to make virtual reality a reality for dogs with the author of this thesis holding thoughts upon moving DCI technology away from a simple sole dog-device practice to a mass-user dog-to-dog system. However, as this thesis advocates, the user centric stance with animals is both possible, and opens the ACI research space into moving away from animals in technology as part of the system into an active end user in which to draw requirements from.

The interaction between the dog owners and their dogs brings those involved an immense amount of happiness and shared love, holding bonds that span a lifetime.

'Dogs are not our whole life, but they make our lives whole.'—Roger Caras

Humans are not always available for their dog, and with dogs often being left alone and potentially suffering from behavioural problems, or dogs required to use technology for work, they are as warranted to benefit from these technology advances, arguably in more ways than the human creators. In this way, dogs deserve technology that is designed for them in a dog-centric manner, with the challenge for the ACI community to make this happen. As this thesis shows, by making the methods focus around the user, results are obtainable that had not previously been possible. These can be captured in a dog-centric manner by simply observing the dog and, from this behaviour, taking away findings that inform the research. In this way, this research forms a contribution towards many dogs that use screen devices to meet the challenges that are presented to them.

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Appendices

1. Dog Personas

1.1 Questionnaire given to owners for Personas

Please see attached CD Appendix 5.1 for questionnaire pdf.

1.2 DataStore for Personas

Please see attached CD Appendix 5.2 for datastore excel file.

2. Dog Information Sheet (DISH)

2.1 Dog Information Sheet

Please see attached CD Appendix 4.1for DISH pdf.

2.2 Dog Information Sheet Questionnaire

Please see attached CD Appendix 4.2 for questionnaire word file.

3. Code for MATLAB Head Tracker

Please see attached CD Appendix 2 for MATLAB code.

4. Dogs Interactions with Media: Dog-centred Approach to see the Interaction between Screens Dataset

Please see attached CD Appendix 3 for excel dataset.

5. DoggyVision: Arduino Code

5.1 DoggyVision: Software

Please see attached CD Appendix 6.1 for full Java Software and enclosed videos and documents.

5.2 DoggyVision: Tracking Arduino Code

Please see attached CD Appendix 6.2 for Arduino file.

5.3 DoggyVision: Results

Please see attached CD Appendix 6.3 for excel sheet.