



# Open Research Online

---

The Open University's repository of research publications and other research outputs

## User Centered Design Approaches to Measuring Canine Behavior: Tail Wagging as a Measure of User Experience

Conference or Workshop Item

How to cite:

Cox, Elizabeth; Ruge, Luisa; Mancini, Clara and Luck, Rachael (2018). User Centered Design Approaches to Measuring Canine Behavior: Tail Wagging as a Measure of User Experience. In: ACI2018 Proceedings of the Fifth International Conference on Animal-Computer Interaction, ACM International Conference Proceeding Series, ACM Digital Library, article no. 1.

For guidance on citations see [FAQs](#).

© 2018 ACM

Version: Accepted Manuscript

Link(s) to article on publisher's website:

<http://dx.doi.org/doi:10.1145/3295598.3295599>

---

Copyright and Moral Rights for the articles on this site are retained by the individual authors and/or other copyright owners. For more information on Open Research Online's data [policy](#) on reuse of materials please consult the policies page.

---

[oro.open.ac.uk](http://oro.open.ac.uk)

# User Centered Design Approaches to Measuring Canine Behavior: Tail Wagging as a Measure of User Experience

**Luisa Ruge**  
The Open University  
Milton Keynes, UK  
luisa.ruge@open.ac.uk

**Elizabeth Cox**  
The Open University  
Milton Keynes, UK  
lizallencox@yahoo.com

**Clara Mancini**  
The Open University  
Milton Keynes, UK  
clara.mancini@open.ac.uk

**Rachael Luck**  
The Open University  
Milton Keynes, UK  
rachael.luck@open.ac.uk

## ABSTRACT

Animal Computer Interaction (ACI) aims to design user-centered interactions between animals and technology. In this regard, a major challenge for researchers is accurately assessing and interpreting animal behavior, in part, due to the invasive nature of data collection techniques and to the individuality of behavior. This paper presents a method that uses tail wagging, a communicative behavior in dogs used in animal behavior and welfare studies, as a non-invasive parameter used to measure canine user experience (UX). We present findings from a study based on an observational analysis of three mobility assistance dogs' tail wagging behaviors and canine personality scores. The findings show tail wagging is a communicative indicator, that the manner in which the tail is wagged correlates to personality, and that tail wagging provides a baseline to assess canine UX. A tail wagging ethogram was used as an evaluative tool for measuring canine UX during task training.

## Author Keywords

Animal computer interaction; tail wagging; user centered design, user experience, canine users, dogs.

## ACM Classification Keywords

H.5.2. User-centered design

## INTRODUCTION

Understanding the interaction between animals and technology is a *“path that seems fraught with obstacles”*, due to the differences in cognitive, physiological and sensory capabilities between humans and animals [31]. When designing technological interactions for animals, these differences inevitably affect the accurate interpretation of animal users' needs, preferences and overall experience, and therefore may result in a poor user experience (UX) for animal users [45].

Due to the individual and contextual variability of behavioral responses to different stimuli, unambiguous and consistent

Paste the appropriate copyright/license statement here. ACM now supports three different publication options:

- ACM copyright: ACM holds the copyright on the work. This is the historical approach.
- License: The author(s) retain copyright, but ACM receives an exclusive publication license.
- Open Access: The author(s) wish to pay for the work to be open access. The additional fee must be paid to ACM.

This text field is large enough to hold the appropriate release statement assuming it is single-spaced in Times New Roman 8-point font. Please do not change or modify the size of this text box.

Each submission will be assigned a DOI string to be included here.

interpretation of behavior is non-trivial. For example, yawning could be a sign of stress in dogs but, depending on the context and on the individual, it could also be a sign of anticipation [17]. Physiological measures are often used by researchers to disambiguate behavior and understand animals' states. However, although parameters such as salivary cortisol, heart rate variability and oxytocin have been proven to be effective indicators [5, 18, 49], their measurement is highly invasive, which compromises their reliability. For example, oxytocin is usually measured by taking a blood sample; in dogs this requires restraint, which makes the collection process stressful [18] and delays the measurement, thus reducing the reliability of collected data.

In spite of these obstacles, in order for ACI to fulfil its core aim of designing technology *for* and *with* animals [30], correctly and accurately interpreting animal behavior is critical, as it is mostly through behavior that users communicate their needs and preferences [37]. Dogs are the most frequent users of technological products [55] and their representation in ACI research is on the increase. Therefore, it is in the interest of ACI researchers to investigate effective approaches to measuring animal behavior.

To this end, the fields of animal behavior and welfare research can offer canine-specific knowledge, helping ACI researchers understand how individual differences within the same species can affect the design, implementation and outcomes of interactive technology for animals [55]. For example, personality assessments help establish individual differences among conspecifics allowing for a better understanding of behavior and coping styles of individuals based on their personality [16, 23]. Additionally, these fields tend to approach the study of animal behavior and welfare by looking at different behaviors in context and producing a more complete picture of an animal's states and responses to stimuli [52].

As of yet, no easy way to measure the canine UX during the elicitation of user needs and preferences, or evaluation of technological interventions exists in ACI. This paper presents a method using tail wagging, a naturally occurring communicative behavior in dogs that is routinely used in animal behavior and welfare studies, as a non-invasive parameter that can be used to measure canine UX. Tail wagging is hypothesized to be a valuable behavioral measure for assessing canine UX, because it is an overt and explicit behavioral expression, a naturally occurring form of

communication and an indicator of emotion in dogs [7, 17, 32]. We explored the applicability of the method through a field study at a Mobility Assistance Dogs (MAD) training centre, where we conducted in depth observations of MADs in training, as they learnt the task of operating an off-the-shelf access button to open a motorized door. The broader aim of the study was to find ways of understanding and assessing canine UX during the interaction with the device, in order to identify user needs and preferences to inform the design of a canine-centred version of the control. Our findings show that tail wagging is a good communicative indicator, and that the manner in which the tail is wagged correlates to the dog's personality, providing a baseline for the use of tail wagging to assess canine UX. We identified and assembled a set of detailed nuances into a tail wagging ethogram and propose that this ethogram can be used as an evaluative tool for measuring canine UX during task training and beyond.

## BACKGROUND

### Mobility Assistance Dogs (MAD)

Dating back at least 12,000 years [13], the long-standing relationship between canines and humans has led to the domestication of the species and resulted in a wide range of working partnerships, such as MAD partnerships. Belonging to the category of assistance dogs, MADs are trained to “assist people with disabilities other than vision or hearing impairment” [1]. Specifically, MADs are trained to perform some of the functions and tasks that an individual cannot perform as a result of their disability, such as assisting with self-care, mobility, and other physical tasks, including opening doors, retrieving objects, and switching lights [33].

Given the range of activities and tasks MADs perform on behalf of their human partners, they are required to interact with a wide variety of products and interfaces in diverse environments [31]. MADs undergo specialized training in which they learn the skills that will help them navigate these challenges. However, most of the environments and the artifacts the dogs are required to interact with reflect an anthropocentric design perspective that fails to recognize MADs as legitimate users and interactors. In spite of the specialized training that MADs undergo to develop the skills they need to work in such anthropocentric environments, they face significant challenges that all too often prevent them from completing their training and consistently performing their assistive work, and that affects their overall welfare [31]. The overall aim of our research is to understand the challenges faced by MADs as well as their usability and user experience requirements, in order to design canine-centered interfaces for the built environment that can enable MADs to work effectively and afford them a better UX.

### Measuring canine UX in ACI

User-centered design (UCD) refers to the design and development of artifacts which place the user at the center of the design process as a means to ensure their needs and preferences are met [2]. Within ACI, the application of a

UCD approach requires human designers to use the best available knowledge of animals needs and preferences [28] and, at the same time, to involve animals as participants in the design process preferably employing naturalistic observational methods [28, 29]. For example, Rault et al. [40] suggest that observing animals in naturalistic settings using non-invasive techniques may result in a more accurate measure of an individual's state and may be more indicative of how an animal may respond to the task they are performing.

If, by observing the animals' behavior during interactions, a measure of the quality of their experience could be assessed, such an assessment would allow the researchers to understand the degree to which animal's user needs are being met, and thus something about the quality of their UX [24]. UX has been described as an individual experience that is dynamic, context-dependent and subjective, stemming from the broad range of potential benefits users may derive from using a product or service [22]. Correspondingly, its assessment ought to somehow account for its dynamic, context-dependent and subjective nature, something which is especially challenging when it comes to canine users.

In an attempt to understand canine UX, existing ACI research has explored a variety of behavioral observation methods. Robinson et al. [42, 43]'s research actively involved canine users as participants in the design process of a canine alarm that was designed to allow medical alert dogs to call for help on behalf of their assisted humans. The authors offered the dogs different low-fidelity prototypes and observed their interaction with these and were thus able to identify the dogs' requirements. While the authors report detailed observations about the way in which the dogs engaged with the prototypes, such observations remained focused on the dogs' performance and did not include subtler behaviors. These behaviors might have signaled different affective states, and their variations, during the interaction, which might have contributed to informing the final design. Taking a more systematic approach to the interpretation of canine behavior, Baskin and Zamansky [4]'s work explored user needs and preferences using an ethogram to assess the animals' behavioral responses while interacting with a digital tablet. Although their approach allowed the authors to establish when behaviors signaling a playful interaction had occurred, the authors' analysis was not detailed enough to enable them to identify and classify subtle variations such as those that indicated enjoyment or displeasure during the interaction.

An example of a more detailed and systematic analysis of animal behavior during an interaction with technology is provided by the work of Paci et al. [35]. The authors conducted a study of domestic cats' responses while wearing biotelemetry collars and, in order to understand the animals' experience, applied an ethological observation method. The observational protocol consisted of measuring the frequency and duration of subtle species-specific behaviors selected

from the feline ethogram, which are known to signal discomfort. Similarly, Jackson et al. [20] studied working dogs' interaction with successive prototypes of a wearable system that enabled them to remotely communicate with their handlers. The authors used a range of metrics relating to the user's individual characteristics as a means to assess their needs and preferences, and thereby evaluate their interaction with the prototypes, with a particular focus on usability. However, in the work of both Paci et al. and Jackson et al., the metrics used by the authors mostly focused on the user's behavioral response while wearing and interacting with the device, without considering how the animals' individual fundamental traits might affect their behavior and its meaning in relation to the animal's experience.

Overall, ACI researchers are adopting and developing increasingly rigorous naturalistic observational methods to interpret animal behavior and assess their requirements during technological interactions in a non-invasive and holistic manner. However, methods that focus on individual differences tend to lack systematicity, methods that are more systematic tend to lack detail, and methods that have both detail and systematicity tend not to account for variations in fundamental individual traits and their implications for the meaning of behavior in relation to user experience, needs and preferences. To bridge this gap, we explore the use of tail wagging as a naturally occurring communicative behavior in dogs that, if systematically analysed against the benchmark of individual fundamental traits, could provide insight into the nuances of dogs' responses to technological interactions, thus shedding light onto how canine users' experience those interactions, and what their needs and preferences might be.

### **Tail Wagging**

Observations indicate that different tail positions or the direction in which the tail wags (left vs right) can mean and communicate different things depending on the duration and intensity of the wag [7, 21, 46]. For example, Kleiman [21] and Bradshaw [7] studied wild and domestic dogs respectively, finding that low tucked-in tails show a lack of confidence as well as submission, that upright tails with a wagging tip show interest, and that relaxed tails where the back-end moves indicate excitement and a desire to play.

Although currently there is no standardization for tail wagging observation, this has been used as a parameter in a number of different studies. By observing tail carriage, Beerda et al. [5] found that high cortisol and a low, or very low posture, with a tail in either a low position or curled forward between the hind legs, was indicative of acute stress. Leaver and Reimchen [25] observed that tail length is an important factor in canine communication and that long tails are more communicative than docked tails. Quaranta et al. [39] found that dogs wagged their tails more to the right when viewing positive stimuli and to the left when viewing unfamiliar or neutral stimuli. McGowan et al. [32] observed an increase in tail wagging frequency in dogs that were

successful in problem solving in order to obtain a food reward. Travain et al. [48]'s research found that tail wagging frequency also increased during a food reward phase.

Although the above studies have considered specific elements of tail wagging, to date no studies have considered additional elements such as the position of the tail, the degree of movement or the way in which the tail wags. For example, Hielm-Björkman et al. [19] looked at frequency of tail wagging, ranging from very often to never, in dogs with chronic osteoarthritis, finding no quantifiable difference. But could they have if they had looked at tail position and how the tail wagged? For example, does the whole tail move from the base of the body or just the tip? Does wagging the tail at the tip mean something different compared to wagging the whole tail? Overall, these studies show that tail wagging is an important parameter which could assist in understanding how dogs communicate their pleasure or satisfaction with an interaction, as well as displeasure or dissatisfaction.

However, not all dogs wag their tail in the same way. Indeed, Handelman [17] showed, not only that tail movements have different meanings, but also that there are breed differences in how dogs wag their tail, suggesting that for a correct interpretation of tail behaviour it is important to establish the natural tail position for the breed. For example, a natural relaxed tail carriage for a Husky is a raised loosely curled tail whereas for a Golden Retriever a natural relaxed tail is carried below the top line of the back. Handelman even notes intra-breed variations from the norm. So, could tail wagging differ in different personality types as it can between and within breeds?

In order to try and understand the subtle nuances involved with tail wagging and their implications for assessing canine UX, this research considered individual tail wagging differences, in terms of subtle wagging patterns, against different dogs' personalities. But what does personality mean when it comes to dogs?

### **Personality**

Personality can be defined as "*Those characteristics of individuals which describe and account for temporally stable patterns of affect, cognition and behaviour.*" [16]. Animal behaviour research has found different ways to measure and assess canine personality such as: (1) by scoring behavior from a battery of tests which the dog has to complete, (2) by asking dogs' carers to complete questionnaires or (3) by free choice profiling where observers choose their own vocabulary to be rated and compare [16, 53]. Canine personality questionnaires, which are completed by the dog's main caretaker, offer a convenient, time efficient and less expensive way to assess personality. Although they have been criticised as being subjective [3], reviews and meta-analysis studies have shown this concern to be ill-founded [41]. For example, well-designed questionnaires, such as the Monash Canine Personality Questionnaire (MCPQ-R), show

high inter-correlation between variables [27] and are highly predictive of future behaviours in dogs [3, 15].

Questionnaires measure personality by scoring fundamental dimensions or traits, such as extraversion or neuroticism [41], which have even been found to be generalisable across species. Studies in dogs have shown that extraverts are more active and sociable whereas neurotics show fearful behaviour and are less inclined to interact with novel tasks [12, 36]. Personality tests tend to measure traits and not specific behaviors such as tail wagging, one exception being that of Svartberg and Forkman [47], who found that confident dogs showed a high tail position with more wagging. Thus, tail wagging could be an indicator of canine personality or, conversely, personality could explain individual differences in tail behavior. While further research is required in this area to better understand associations between personality and tail wagging, the correlation between the two could be exploited when assessing dogs' responses to technological interactions and their implications for canine UX.

## THE STUDY

### Research context

As a part of a larger project into the influence of task training on the complete MAD UX, we carried out a study at the facilities of a UK Charity that partners people living with disabilities and specially trained dogs. Here, dogs undergo specialized training lasting 16 weeks, during which they learn all the behaviors they are expected to perform in order to become MADs. One such category of behaviors is known as task commands, with the main behaviours being referred to by the commands “*push*” (using paws to push objects), “*nudge*” (using snouts to push objects), “*pull*” (using mouth to pull objects), and “*retrieve*” (picking up objects and returning them). All commands are taught incrementally through small behavioral changes, using positive reinforcement and clicker training techniques [38]. For example, the “*push*” command is used for tasks such as pushing an access button. To learn to perform this task, the dogs first learn to approach (with their snouts or paws) a wooden target that has been placed on the floor, then they are taught to press or push the target until trainers evidence a good amount of pressure being used. Once the dogs have learned the functional aspect of the “*push*” command, the wooden target is moved around the floor, and placed on the wall to get the dogs used to carrying out different postures to operate the target. Then the wooden target is reduced in size or placed over the real buttons until it can be phased out and the dogs learn to interact with the buttons directly. The final step involves exposing the dogs to a large variety of buttons and button placements so that they can start to generalize the “*push*” command to any situation they might encounter in their working lives.

During the more advanced stages of push task training, in order to mimic the dogs' future working conditions, usually the trainer uses a mobility aid, such as a wheelchair, to

approach a door next to which an automatic access button is fitted. The trainer then issues the “*push*” cue to the dog, usually while looking at the button, or using their fingers to point towards it. The dog is then expected to approach the button and push it using either their snout or paws. Due to the variability in button height (in addition to size, shapes materials and required activation pressure) encountered in real world environments, dogs sometimes have to jump up in order to reach and operate the button. Once the dog has successfully pushed the button the trainer marks the behavior with the sound of a clicker and offers the dog a food reward. We were interested in understanding the dogs' responses during their interaction with the buttons; in particular, we wanted to see how they might be affected by the interaction, even though they were now proficient in performing the task.

To control for environmental variables and to exclude any environmental sensitivity that might have affected the participants, although some training sessions are held in a nearby town's shops and residential areas, for this study all the sessions took place at the Charity's training facility.

### Research participants

Three MADs in-training and their trainers took part in the study. Canine participants were two black Labrador cross Golden Retrievers, one male (Odin, born March 2016) and one female (Lucy, September 2016), and one golden retriever, male, (Zion, September 2016). All dogs had been neutered. The dogs were at the end of their 16-week training period and were fully trained to push access buttons to open doors.

### Data collection and analysis

We video recorded the activity of the dogs during “*push*” task training sessions, during which they were asked by their trainers to operate access buttons. All video and audio recordings were obtained using a handheld GoPro Hero 4 camera and analyzed using Windows Movie Maker (V8.0.2.0).

Eight video clips of training sessions were selected for analysis, as they showed successful and unsuccessful button pushes and contained enough clear footage of the dogs' tail. The clips were analyzed using Windows Movie Maker (V8.0.2.0) as this software allowed a frame by frame analysis similar to the methods used by Quaranta et al.[39]. Given the speed of tail movement, frame by frame analysis is essential to understand its details. Analysis was done in two parts “before” and “after”. “Before” - tail wagging was observed from the moment the command “*push*” was given (verbally or by pointing) and stopped when the dog reached the button. “After” – tail wagging was observed once the dog had either pushed the button with its snout or returned all four paws to the floor after having used their paws to push.

Data from the video clips was captured in excel by noting specific tail movements and what dog and trainer were doing at the exact time that the observed movements occurred. The tail wagging behavior of the three dogs was then compared

with their personality scores, their actions and with their failure and success rates during the “push” task. Failure was defined as the dog touching the button in one way or another, but not activating the door-opening mechanism; conversely, success was defined as the dog pushing the button and activating the door-opening mechanism.

For each dog, we also completed a canine personality assessment questionnaire. Participant personalities were assessed using the MCPQ-R [26] questionnaire, evidenced to be a reliable and consistent personality measurement tool [26, 27], unlike other personality tests, such as C-BARQ, whose focus is limited to a certain period of the dog’s development or to measuring the prevalence and severity of behavioural problems. The MCPQ-R is an adjective based test which uses five dimensions to rate personality traits (neuroticism, extraversion, motivation, training and focus and amicability) through a Likert Scale rating system where 1 means “really does not describe my dog”, to 6 which means “really describes my dog”. The adjectives on the test are randomized so as not to fall into groupings for each dimension and to reduce proximity error [26]. The overall ratings were calculated to show a percentage score for each dimension. The questionnaires were completed by each of the dogs’ trainers because of their experience and knowledge of the dogs’ behaviors [26].

**Tail Wagging Ethogram**

As mentioned above, no tail wagging ethogram currently exists and previous research using tail wagging as a parameter has not followed a standardized protocol, making data difficult to compare. With this in mind, based on observations from the video analysis, we derived an ethogram that integrates tail position, direction and angle of wagging in order to account for the tail wagging nuances previously discussed. We used Grounded Theory, which allows the creation of a theoretical framework where none exists [50, 54]. During task training interactions, tail wagging was a fairly easy behaviour to observe. However, upon starting data analysis, the researchers realized that even though the basic behavior of tail wagging was fairly easy to quantify (number of wags, direction of wags and position of tail during wags), the tail wagging behaviors would quickly change during the interaction, making them hard to record. Thus, a frame by frame analyses of the video ensued which allowed a more rigorous analysis of the behavior, and in addition made the researchers aware of a wider range of tail wagging behaviors than we thought to be worth recording. Initially, the focus had been on frequency, direction, position and angle; however, the dogs also showed variation in the movement of the tail tip. Thus, the ethogram evolved to include this new tail wagging parameter (See Figure 1).

Tail position was assessed by observing the dog’s carriage of their tails and categorized into (1) high (any position above horizontal), (2) horizontal (holding tail horizontal in line with the spine), and (3) low (any position below horizontal). Tail direction was assessed by looking down at the dog’s

back and logging movement to either the dog’s right or left. Midline was used when the tail was held in a central position in line with the spine. Tail angle was divided into six possible positions, by looking down at the dog’s back. A 90° wag was logged for a full wag which meant the tail finished at a 90° right angle to the body on either the left or right side. Halfway was logged as 45° and a wag between the midline and 45° was logged as <45°. Tail tip movement was logged in a similar way. See Figure 1 for details. Although not a definitive ethogram of all tail activity, and although further research is needed in order to ascertain reliability, validity and consistency [16], this is considered a useful basis to analyze different tail wagging behaviors.

Participant: Odin



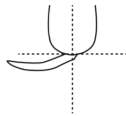

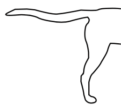

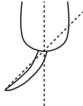


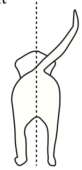
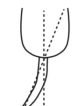

| Tail Position  | Tail Direction   | Tail Angle  | Tail Tip Angle   |
|--|--|---|--|
| High<br>        | Left<br>    | 90°<br>    | Tip 90°<br>       |
| Horizontal<br> | Center<br> | 45°<br>   | Tip 45°<br>      |
| Low<br>       | Right<br> | <45°<br> | Tip at <45°<br> |

Figure 1: Tail Wagging Ethogram

**FINDINGS**

**Overview**

Analysis of tail wagging in the video clips showed individual differences between the three dogs in their tail wagging behavior for position (Figure 2), direction (Figure 3) and angle (Figure 4). Overall, Lucy showed a higher 90° or 45° wag with no particular difference between the left or right side. Odin’s tail was either in the high or horizontal position with a strong 90° or 90° tip wag and a preference for right sided wagging. In contrast, Zion’s tail was either in the horizontal to low position with strong 90° and 90° tip wagging and a preference to wag to the left.



Figure 2. Individual tail wagging position (high, horizontal, low), difference between study participants.

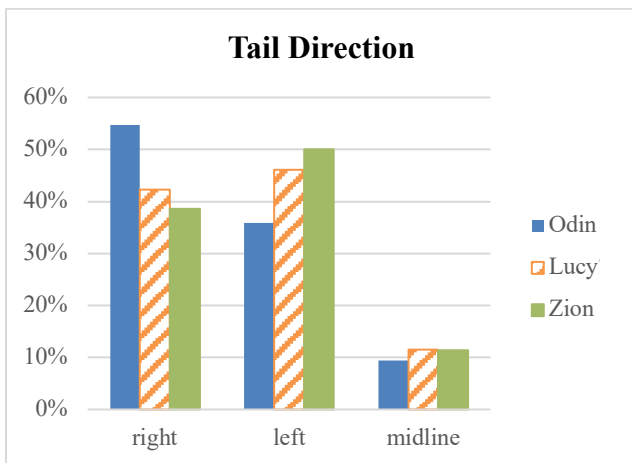


Figure 3. Individual tail wagging direction (left, right, midline), difference between study participants.

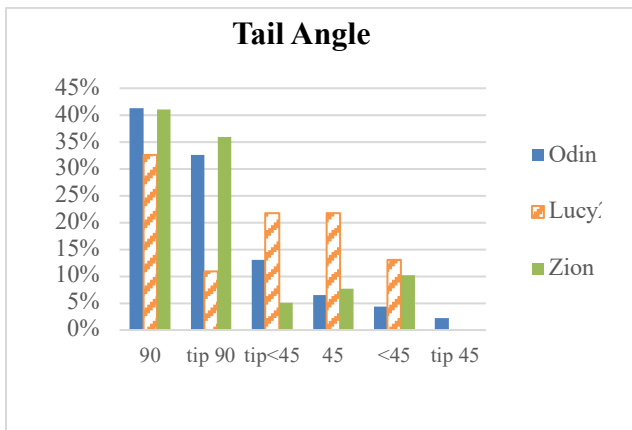


Figure 4. Individual tail wagging angle (90°, tip 90°, 45°, tip 45°, <45°, tip <45°), difference between study participants.

Figures 5, and 6 show Lucy and Zion during their “push” command training sessions. Figure 5 shows Lucy having to jump up in order to reach the button while exhibiting a tail wag to the right. Figure 6 shows Zion approaching the button with his snout while exhibiting a horizontal tail wag to the left.



Figure 5: Lucy having to jump up to press the button while exhibiting a high 90° tail wag.



Figure 6: Zion approaching the access button while exhibiting a horizontal tail wag.

Odin scored the highest in terms of extraversion (77.7%), with Lucy a close second (67.7%) and Zion, further down the scale (44.4%). In terms of motivation, Odin scored the highest (80%), with Lucy and Zion further down the scale with 66.7% and 63.3% respectively. All dogs scored similarly in terms of training and focus with Odin scoring a bit lower (77.8%) as opposed to Lucy and Zion which shared a 86.1% score. All dogs scored closely in terms of amicability with Odin at 80%, Lucy at 83.3% and Zion at 86.7%. In terms of neuroticism Zion scores the highest at 54.2%, followed by Lucy at 45.78% and Odin at 29.2%. Results can be seen along the range from 0%-100% of potential scores in Figure 7.

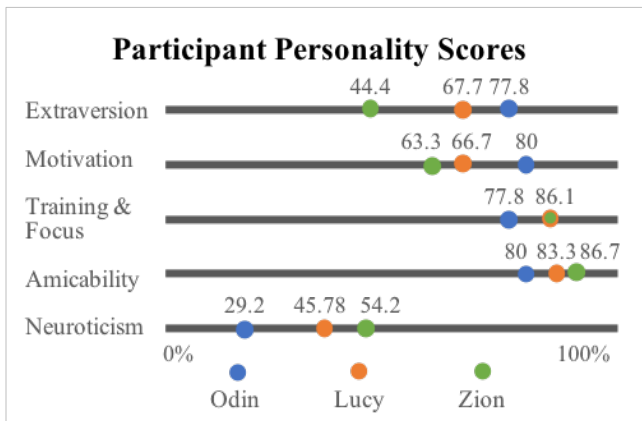


Figure 7: Combined participant results of MCPQ-R personality questionnaire.

### Tail Wagging as an Individual Characteristic

The findings evidence tail wagging behaviors to be characteristic to each participant. Although only 3 dogs participated in the study, there seems to be enough data to support the hypothesis that each dog wags its tail in a unique manner. Odin's tail wag could be generally described as having a tendency towards a high (46%) and horizontal (46%) tail position, with a preference towards right sided wags (55%) and an angle of tail movement at 90° (41%) or a 90° tail tip movement (33%). Lucy's tail wagging has a significant tendency towards a high tail position (69%), with a fairly equal preference for wagging her tail to the left (46%) and right (42%), with a preference (33%) towards a 90° angle. Zion's tail position exhibits an equal preference between a horizontal (38%) and low (41%) position, a tendency towards a left sided wag (48%) compared to right (40%) and midline (10%) wags respectively, and an angle of tail movement at 90° (41%) or a 90° tail tip movement (36%).

### Tail Wagging and Personality

When compared to their personality assessments, the characteristic tail wagging behaviors described above correlate to their personality scores. In the case of Odin, it is interesting to note that having scored higher on extraversion (77.8%) he exhibited a greater number of tail wags in the high and horizontal position (92%) and to the right (54%). He also showed consistent 90° wagging of the whole tail or tip (74%) behavior which Svartberg and Forkman [47] found consistent with that of confident dogs. In contrast, Zion scored more highly on neuroticism and showed consistent 90° wagging of the whole tail and tip (77%) but with his tail in the horizontal or low position (77%), which has been shown to indicate lack of confidence and submission [21] or, as proposed by Handelman [17], could be a breed-specific trait to Golden Retrievers. Lucy scored mid-range for both extraversion and neuroticism. Of the three dogs she showed the greatest variation in the angle at which her tail wagged. 44% of her wags were full or tip 90° wags, 22% were at an angle of 45° and 35% were at an angle of <45° (tip and full). However, her tail position was predominantly high (69%) and she showed a fairly equal

preference for wagging her tail to the left and right (L:46%, R:42%). These findings could indicate that tail wagging at an angle of 45° or <45° (tip or full tail) show uncertainty in a dog that is both confident and submissive.

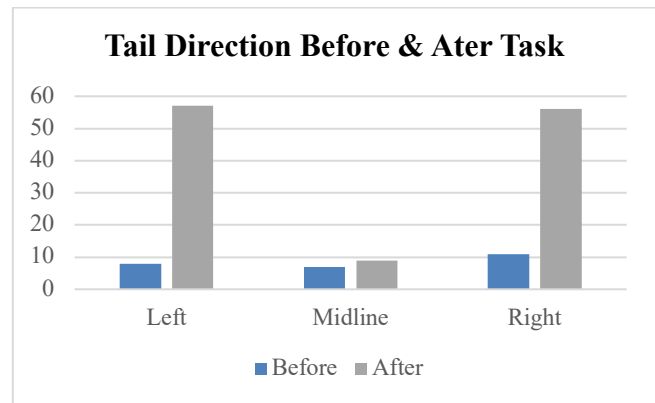


Figure 8: Combined participant tail wagging direction before and after completing the "push" task

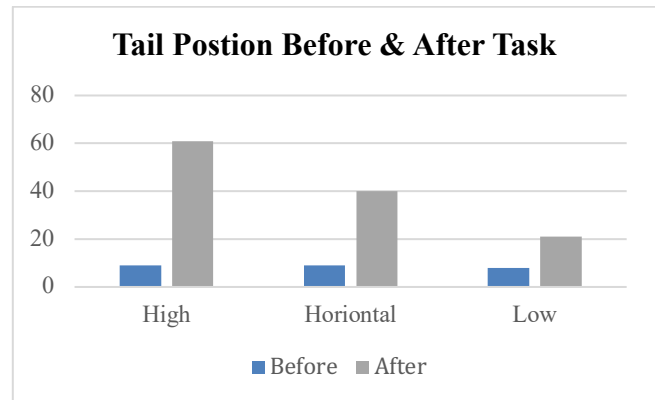


Figure 9: Combined participant tail wagging positions before and after completing the "push" task

### Tail Wagging Before and After a Task

The findings also revealed a change in tail wagging behaviors among all participants before and after the task of pushing the button. A focus on these changes in behavior could potentially be used as a means to inform the quality of the interaction in order to gain a measure of canine UX. This focus is supported by a similar approach present in anthropocentric research methods where data is collected before and after a user has completed a task in order to qualify satisfaction [37].

### Frequency

The findings show that all three dogs had increased tail wagging behavior after attempting to push the button (122 wags) as opposed to before (26 wags). This could in part be explained due to the variability in the timing of receiving the food reward after completing the task as experienced by the participants, which ranged from 3 seconds to 5 seconds or longer when on a few occasions the trainer's started to maneuver the wheelchairs away from the button before



rewarding. Thus, the dogs could be exhibiting an increase in tail wagging in anticipation of the reward, or to get the trainer's attention and thus get the reward, or because they were confused with the delay and thus slightly aroused [17].

The study also considered individual differences in tail wagging behaviour before and after the task. Zion barely wagged his tail before the task (before = 3 wags, after = 41 wags) whereas both Lucy and Odin showed fairly equal numbers (Odin before = 12; after = 39) (Lucy before = 10; after = 42). This could be explained as a breed difference, since Zion is a Golden Retriever and Lucy and Odin are both Labrador cross Golden Retrievers [17]; or alternatively it could be due to assistance dogs having a lower baseline arousal before a task compared to pet dogs [9].

#### *Direction*

Before the task was completed the direction of tail wagging showed a slight preference towards the right (right = 11; left = 8), a behaviour which could indicate a left hemisphere bias. This assumption is supported by the fact that the left hemisphere is in control of routine and learnt behaviour. Indeed, since all participants had completed their training, the task would likely be familiar and easy for them to perform. After the task, direction of wagging was almost equally split with 57 wags towards the left and 56 towards the right (see Figure 8).

#### *Angle*

Before completing the task participants showed a greater number of 90° tip wags (tip 90° = 7; 90° = 3) whereas after the task a greater number of full 90° wags were noted (90° = 47; tip 90° = 27). The findings suggest that the dogs were slightly aroused before the task, probably in anticipation of the food reward, and thus arousal levels increased after the task because a reward was now expected. This increase in arousal as related to the expectation of food reward was evidenced in the work of [32, 48]. However, as previously mentioned, the angle of tail wagging should be researched in more detail to define what different tail wagging angles communicate.

#### *Position*

While Lucy and Zion's tail remained consistent in position before and after the task, Odin had a tendency towards a higher number of horizontal positions before the task and high and horizontal positions after the task. Odin scored highly on motivation (80%) yet received the lowest number of rewards mainly due to him having the highest amount of failed button pushes (See Figure 9). Could the difference in his tail position reflect a lack of understanding in what was required to get the treat and therefore a decrease in his motivational state?

#### **Tail Wagging and Failed Attempts**

As mentioned above, during data analysis, a failed attempt was defined as one in which the dog came into contact with the button but did not manage to push it in a way that activated the door. A failed attempt did not receive a food reward and the dog was asked to repeat the task. Upon further

discussion among the research team of other behaviors noted between the dogs, it emerged that, although there was a straightforward distinction between success and failure for both trainers and researchers, this was not the case for the dogs. For them the task seems to end the moment they have come into some sort of contact with the button, and not with the door opening.

This was evidenced by both Odin and Lucy in different ways. After a failed attempt, Odin continued to repeat the button pushing action when commanded whereas Lucy, who had the lowest number of failed attempts, showed what could be considered distraction or displacement behavior after a failed attempt. In spite of being given the command to push the button again, Lucy turned away in the opposite direction. Her tail wagging during this period remained high, but she showed more 45° wagging (11 wags) than 90° wagging (8 wags). The behavior and the difference in tail angle and direction could indicate that Lucy was under stress at this time reflecting on her individual UX. In contrast, Zion spontaneously pushed the button 4 times even though he had not been given the command. Zion scored more highly on training and focus with 86.1%, so this behavior could indicate his learnt ability to induce his trainer into give him more food rewards with spontaneous button pushes, regardless of their success or failure. Lucy also scored highly on training and focus (86.1%) however unlike Zion she also scored more highly on extraversion (66.7%), which could account for increased arousal affecting her ability to carry out the task (See Figures 11 and 12) [9].

#### **Tail Wagging and Laterality**

Based on the research team's expertise in laterality, defined as '*the preferential use of one side of the body over another*' [6], tail wagging was identified as a potential indicator of hemispheric dominance. This is where a preferred part of the body indicates dominance of the opposite brain's hemisphere (i.e. in a right-handed person the left hemisphere is the dominant one) [44]. The left hemisphere of the brain is believed to control routine behaviour and proactivity; and reflects a positive cognitive bias. On the other hand, the right hemisphere controls the hypothalamic-pituitary-axis (HPA) and the emergency response; it is reactive and reflects a negative cognitive bias [44]. In human subjects, left handed people are more likely to show depressive symptoms [14] and left-pawed dogs were found to have a more negative cognitive bias [51].

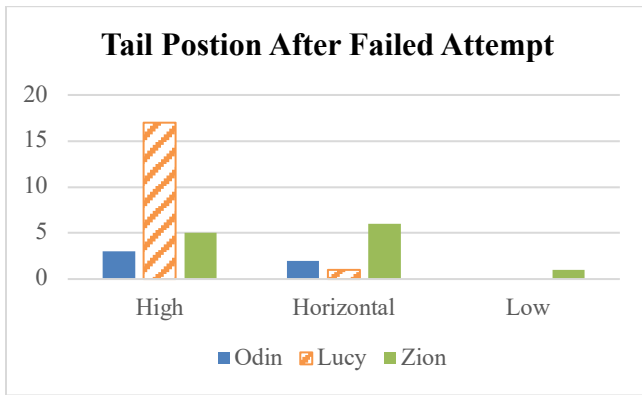


Figure 10: Participant tail wagging position after failed attempt of "push" task

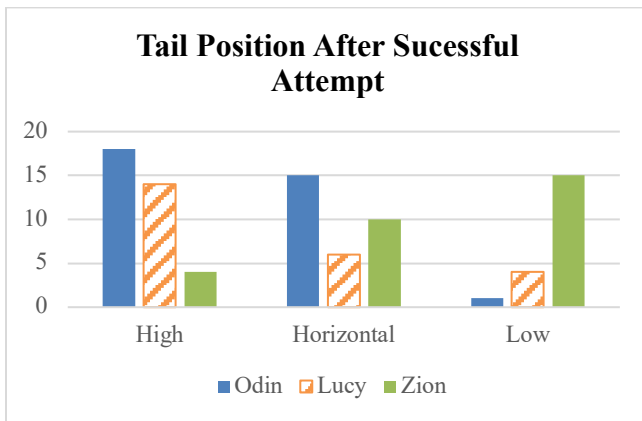


Figure 10: Participant tail wagging position after successful attempt

Research in dogs has shown that different behaviors are reflected in either dominance or a lack of dominance of a brain hemisphere[8]. Although canine laterality research has mainly looked at the preferential use of one paw over another [53], there is evidence to suggest that asymmetric wag of the tail could also show which hemisphere of the brain is dominant [39]. This is due to a dog's tail, although a medial organ, being an extension of the spinal column [10]. It is therefore likely that the direction in which a tail wags could reflect either dominance of one hemisphere over the other or the preferential use of one hemisphere for a particular task [53], i.e. either left hemisphere (expressed by a right tail wag) or right hemisphere (expressed by a left tail wag) [40]. For example, overall Lucy showed a fairly equal tendency for left and right tail wags (9L:46%, R:42%). However, after failing the task she showed more tail wags to the left than to the right (11 against 6), which could indicate that the right hemisphere was more active during this period. The right hemisphere controls the stress response [44].

Analysing tail wagging against the individual benchmarks of personality and laterality could provide ACI researchers who work with dogs with valuable information about the response of canine users to technological interactions. Helping them

better understand the animals' needs and preferences thus leading to improved user experience.

### Tail Wagging as a Measure of Canine UX

It was evident from the data that food rewards were highly motivating for the dogs with all three focusing 59% of their attention on either the treat bag or 17% on the trainer as opposed to the door (13%). It could be hypothesized that, because the distinction which determines whether they get or do not get a treat is unclear, the dogs are either exhibiting an increase in tail wagging in order to get the trainer's attention and hopefully get a reward, or because they are confused and thus slightly aroused. These behaviors, as previously discussed, are consistent with an increase in tail wagging [17], which was evidenced in all three participants after the task.

The behaviors described above when put within the context of canine task training, reveal that the dogs seemed the most interested in the task after failing, this could be due to having to reduce for the delay in the food reward, for example as evidenced by Odin's continued attempts at pushing the button. Here, one could argue that because the dog's interest is solely focused on the food reward, regardless of the task being performed, any task rewarded with food would afford good UX. On the other hand, one could argue that the food reward only adds complexity to the interaction, confusing the difference between success and failure for the dogs and thus should be taken out completely. Either way, both explanations imply that, in order to afford good canine UX, the task should present the dog with a clear objective to be achieved in order to complete the task. For example, the trainer could delay the food reward until after the door had opened and the threshold had been crossed, or the door itself could communicate success to the dog through a specific sound, or possibly offering the reward itself.

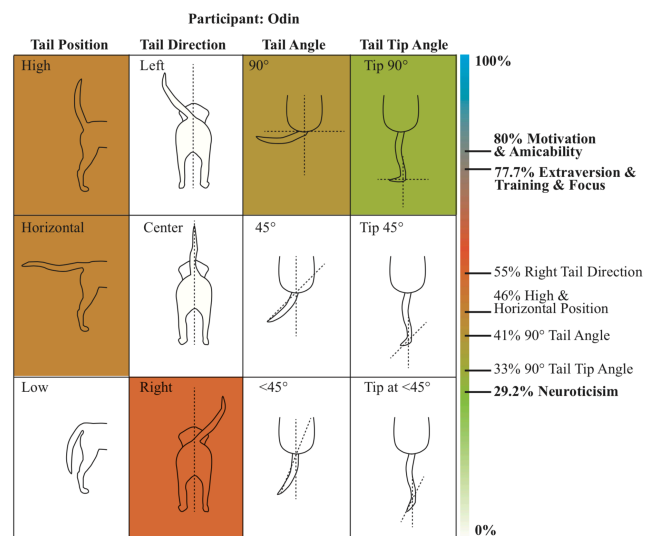


Figure 12: Example of Odin's pre-study ethogram

## DISCUSSION

The above findings suggest that tail wagging is a measurable behavioral parameter which, when observed in detail against individual behavioural characteristics, provides valuable information towards understanding and potentially measuring canine UX. In addition, the findings show that differences in tail wagging among participants correlate with their personality assessment scores and, based on laterality, could indicate which hemisphere is dominant.

### Advantages & limitations of the tail wagging ethogram

We explored the potential of this evaluation method during an empirical study of MADs in training and, based on our findings, propose a tail wagging ethogram that can be used as an evaluative tool for measuring canine UX. Although a more nuanced tool to capture and record tail wagging behavior could be used as a baseline to capture personality and laterality for each participant in order to better and more accurately interpret tail wagging behavior during task training. For example, in the case of Odin, the ethogram could first be used as a means to capture his personality test scores (Extraversion: 77.7%, Motivation (80%), Training and Focus (77.8%), Amicability (80%), and Neuroticism (29.2%) in a way that was easy to access during future observations sessions. The ethogram could then be used to score participant individual tail wagging traits and possible indications of laterality, through a pre-study observation protocol. Odin's tail wagging would have a tendency towards a high (46%) and horizontal (46%) tail position, a preference towards right sided wags (55%) and an angle of tail movement at 90° (41%) or a 90° tail tip movement (33%), potentially indicating left hemispheric dominance.

Once these baselines were established, the individualized ethogram would then be used for studies in which that particular participant was involved (See Figure 12).

### Tail Wagging as a Baseline for Future Studies

While, in this study, tail wagging emerges as a behavioral parameter that could be used by researchers to assess canine UX, differences in communicative behavior between full tail wags and tip-only wags remain unclear. This suggests the need for further research into these nuances. In addition, the possibility of using tail wagging as a measure of the dogs' communicative baseline should also be further explored. Understanding the typical tail wagging behavior exhibited by each participant would make it possible to assess how they communicate, which would increase the accuracy of future canine UX assessments. In addition, the baseline could also provide a more nuanced interpretation of the tail wagging ethogram, potentially leading to a better understanding into the quality of the canine UX.

### Measuring the Animal UX

Measuring the UX is a subjective process, in part due to its individualistic and non-utilitarian nature, its malleable unit of analysis and the variety of seemingly fuzzy concepts with which it is associated [24]. When trying to understand and measure the animal UX the question of what an experience

means and what we are hoping to measure is important to address. Is our intent to understand the experience itself, which could be argued we do not have access to, or are we trying to interpret the animal's behavior and responses assuming that these are a reflection of their experience? Probably both. The communication gap between researchers and research participants in ACI research is currently approached by using animal behavior as a means to analyse more objective measures such as usability [11, 34, 45]. We suggest that, in order to measure animal UX we could use similar methods by taking an approach in which the nuances of behavior, the background of the user (personality) and the context in which the user operates are all taken into account and interpreted in a holistic way in order to try and make sense of the animal UX, at least to a level of approximation that is good enough to iteratively orient the design process.

### Study Limitations

This study is a first attempt at validating the use of tail wagging ethogram, against personality assessment, as a measure of canine UX. In order to further establish this indicator, data collection from larger groups of mixed-breed participants is advised. This would allow for the analysis of a range of behavioural (e.g. speed) and contextual (e.g. distractors) variables related to tail wagging. Other emerging behavioural patterns could help us discern the impact of rewards (e.g. food or toys) on current operant conditioning training techniques. In future studies, task behavior (e.g. pushing the button) could be marked following the task outcome (e.g. once the door opens) to help the user understand the task.

## CONCLUSION

Tail wagging is a good indicator of canine communicative behavior, whose observation, assessment and interpretation can be easily carried out in naturalistic settings. Furthermore, initial findings from our study show a correlation between how dogs wag their tails and their personality, allowing for a baseline of individual canine behavior to be established, against which to more accurately interpret tail wagging behavior. This paper presents the results of a field study involving three MADs, during which a tail wagging ethogram was used to aid observation and measure canine UX. Findings suggest that the tail wagging ethogram provides a useful approach to measuring canine behavior during technological interactions, which could help ACI researchers elicit user needs and preferences during the design and development process.

## ACKNOWLEDGEMENTS

We thank Dogs for Good and their staff, who have welcomed us into their facilities and participated in this research, providing invaluable support and insight. We are especially grateful to Leanne Carmichael and Duncan Edwards. This research is funded by Pet Plan Charitable Trust.

## REFERENCES

- [1] Assistance Dogs International. Retrieved from <https://www.assistedogsinternational.org/>.

- [2] C. Abras, D. Maloney-Krichmar and J. Preece. 2004. User-Centered Design. In *Encyclopedia of Human-Computer Interaction*, Sage Publications, Thousand Oaks.
- [3] S. Barnard, D.L. Wells, P.G. Hepper and A.D.S. Milligan. 2017. Association between Lateral Bias and Personality Traits in the Domestic Dog (*Canis Familiaris*). *Journal of comparative psychology* [online].
- [4] S. Baskin and A. Zamansky. 2015. The Player Is Chewing the Tablet! In *Proceedings of Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play - CHI PLAY '15*. 463-468. <http://dx.doi.org/10.1145/2793107.2810315>
- [5] B. Beerda, M.B. Schilder, N.S. Janssen and J.A. Mol. 1996. The Use of Saliva Cortisol, Urinary Cortisol, and Catecholamine Measurements for a Noninvasive Assessment of Stress Responses in Dogs. *Hormones and behaviour* 30, 3, 272-279.
- [6] C. Berta. 2011. Lateralized Behavior in Domesticated Dogs. *ESSAI* 8, 1, 1-4.
- [7] J. Bradshaw. 2012. In *Defence of Dogs*. Penguin Books Ltd, London.
- [8] N.J. Branson and L.J. Rogers. 2006. Relationship between Paw Preference Strength and Noise Phobia in *Canis Familiaris*. *Journal of Comparative Psychology* 120, 3, 176-183.
- [9] E.E. Bray, E.L. MacLean and B.A. Hare. 2015. Increasing Arousal Enhances Inhibitory Control in Calm but Not Excitable Dogs. *Anim Cogn* 18, 6, 1317-1329. <http://dx.doi.org/10.1007/s10071-015-0901-1>
- [10] D.F. Buxton and D.C. Goodman. 1967. Motor Function and the Corticospinal Tracts in the Dog and Raccoon. *Journal of Comparative Neurology* 129, 4, 341-360.
- [11] C. Byrne, L. Freil, T. Starner and M.M. Jackson. 2017. A Method to Evaluate Haptic Interfaces for Working Dogs. *International Journal of Human-Computer Studies* 98, 196-207. <http://dx.doi.org/10.1016/j.ijhcs.2016.04.004>
- [12] L.O. Carrier, A. Cyr, R.E. Anderson and C.J. Walsh. 2013. Exploring the Dog Park: Relationships between Social Behaviours, Personality and Cortisol in Companion Dogs. *Applied Animal Behaviour Science* 146, 1, 96-106.
- [13] S.J.M. Davis and F.R. Valla. 1978. Evidence for Domestication of the Dog 12,000 Years Ago in the Natufian of Israel. *Nature* 276(5688), 608-610. <http://dx.doi.org/10.1038/276608a0>
- [14] K. Denny. 2009. Handedness and Depression: Evidence from a Large Population Survey. *Laterality: Asymmetries of Body, Brain and Cognition* 14, 3, 246-255.
- [15] P. Foyer, N. Bjällerhag, E. Wilsson and P. Jensen. 2014. Behaviour and Experiences of Dogs During the First Year of Life Predict the Outcome in a Later Temperament Test. *Applied Animal Behaviour Science* 155, 93-100.
- [16] S.D. Gosling. 2008. Personality in Non-Human Animals. *Social and Personality Psychology Compass* 2, 2, 985-1001.
- [17] B. Handelman. 2008. *Canine Behavior: A Photo Illustrated Handbook*. First Stone,
- [18] L. Handlin, E. Hydbring-Sandberg, A. Nilsson, M. Ejdebäck, A. Jansson and K. Uvnäs-Moberg. 2011. Short-Term Interaction between Dogs and Their Owners: Effects on Oxytocin, Cortisol, Insulin and Heart Rate—an Exploratory Study. *Anthrozoös* 24, 3, 301-315.
- [19] A.K. Hielm-Björkman, E. Kuusela, A. Liman, A. Markkola, E. Saarto, P. Huttunen, J. Leppäluoto, R.M. Tulamo and M. Raekallio. 2003. Evaluation of Methods for Assessment of Pain Associated with Chronic Osteoarthritis in Dogs. *Journal of the American Veterinary Medical Association* 222, 11, 1552-1558.
- [20] M.M. Jackson, G. Valentin, L. Freil, L. Burkeen, C. Zeagler, S. Gilliland, B. Currier and T. Starner. 2014. Fido—Facilitating Interactions for Dogs with Occupations: Wearable Communication Interfaces for Working Dogs. *Personal and Ubiquitous Computing* 19, 1, 155-173. <http://dx.doi.org/10.1007/s00779-014-0817-9>
- [21] D.G. Kleiman. 1967. Some Aspects of Social Behavior in the Canidae. *American Zoologist* 7, 2, 365-372.
- [22] D. Knemeyer and E. Svoboda. 39. User Experience – Ux Retrieved from <https://www.interaction-design.org/literature/book/the-glossary-of-human-computer-interaction>.
- [23] J.M. Koolhaas, S.M. Korte, S.F. De Boer, B.J. Van Der Vegt, C.G. Van Reenen, H. Hopster, I.C. De Jong, M.A.W. Ruis and H.J. Blokhuis. 1999. Coping Styles in Animals: Current Status in Behavior and Stress-Physiology. *Neuroscience & Biobehavioral Reviews* 23, 7, 925-935.
- [24] E.L.-C. Law, R. V., M. Hassenzahl and J.K. Arnold P.O.S. Vermeeren. Year. *Understanding Scoping and Defining the User Experience: A Survey Approach*. In *Proceedings of CHI 2009*.
- [25] S.D.A. Leaver and T.E. Reimchen. 2008. Behavioural Responses of *Canis Familiaris* to Different Tail Lengths of a Remotely-Controlled Life-Size Dog Replica. *Behaviour* 145, 3, 377-390.
- [26] J.M. Ley, P.C. Bennett and G.J. Coleman. 2009. A Refinement and Validation of the Monash Canine Personality Questionnaire (Mcpq). *Applied Animal Behaviour Science* 116, 2, 220-227.
- [27] J.M. Ley, P. McGreevy and P.C.b. Bennett. 2009. Inter-Rater and Test–Retest Reliability of the Monash Canine Personality Questionnaire-Revised (Mcpq- R). *Applied Animal Behaviour Science* 119, 1, 85-90.
- [28] C. Mancini. 2011. *Animal Computer Interaction: A Manifesto*. *Interactions* July+August, 69-73.
- [29] C. Mancini. 2013. *Animal Computer Interaction (Aci): Changing Perspective on Hci, Participation and Sustainability*. In *Proceedings of CHI 2013: Changing Perspectives*. Paris, France.
- [30] C. Mancini. 2017. Towards an Animal Centered Ethics for Animal-Computer Interaction. *International Journal Human-Computer Studies* 98, 221-233. <http://dx.doi.org/10.1016/j.ijhcs.2016.04.008>

- [31] C. Mancini, S. Li, G. O'Connor, J. Valencia, D. Edwards and H. McCain. 2016. Towards Multispecies Interaction Environments: Extending Accessibility to Canine Users. In Proceedings of Proceedings of the Third International Conference on Animal-Computer Interaction - ACI '16. 1-10. <http://dx.doi.org/10.1145/2995257.2995395>
- [32] R.T.S. McGowan. 2014. Positive Affect and Learning: Exploring the “Eureka Effect” in Dogs. *Animal Cognition* 17, 3, 577-587.
- [33] T. Muto. Service Dog Definition. Retrieved from <http://www.canineprofessionals.com/service-dog-definition>.
- [34] P. Paci, C. Mancini and B.A. Price. 2017. The Role of Ethological Observation for Measuring Animal Reactions to Biotelemetry Devices. In Proceedings of Proceedings of the Fourth International Conference on Animal-Computer Interaction - ACI2017. 1-12. <http://dx.doi.org/10.1145/3152130.3152144>
- [35] P. Paci, C. Mancini and B.A. Price. Year. The Role of Ethological Observation for Measuring Animal Reactions to Biotelemetry Devices. In Proceedings of ACO 2017. ACM.
- [36] T.C. Plueckhahn, L.A. Schneider and P.H. Delfabbro. 2016. Assessing Lateralization in Domestic Dogs: Performance by *Canis Familiaris* on the Kong Test. *Journal of Veterinary Behavior: Clinical Applications and Research* 15, 25-30.
- [37] J. Preece, H. Sharp and Y. Rogers. 2015. *Interaction Design: Beyond Human-Computer Interaction* (4th). John Wiley & Sons,
- [38] K. Pryor. 2005. *Clicker Training for Dogs (Getting Started)*. Sunshine Books,
- [39] A. Quaranta, M. Siniscalchi and G. Vallortigara. 2007. Asymmetric Tail-Wagging Responses by Dogs to Different Emotive Stimuli. *Curr Biol* 17, 6, R199-201. <http://dx.doi.org/10.1016/j.cub.2007.02.008>
- [40] J.-L. Rault, S. Webber and M. Carter. 2015. Cross-Disciplinary Perspectives on Animal Welfare Science and Animal-Computer Interaction. In Proceedings of Proceedings of the 12th International Conference on Advances in Computer Entertainment Technology - ACE '15. 1-5. <http://dx.doi.org/10.1145/2832932.2837014>
- [41] D.J. Rayment, R.A. Peters, L.C. Marston and B. De Groef. 2016. Investigating Canine Personality Structure Using Owner Questionnaires Measuring Pet Dog Behaviour and Personality. *Applied Animal Behaviour Science* 180, 100-106.
- [42] C. Robinson, C. Mancini, J. van der Linden, C. Guest, L. Swanson, H. Marsden, J. Valencia and B. Aengenheister. 2015. Designing an Emergency Communication System for Human and Assistance Dog Partnerships. In Proceedings of Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing - UbiComp '15. 337-347. <http://dx.doi.org/10.1145/2750858.2805849>
- [43] C.L. Robinson, C. Mancini, J. van der Linden, C. Guest and R. Harris. 2014. Canine-Centered Interface Design: Supporting the Work of Diabetes Alert Dogs. In Proceedings of Proceedings of the 32nd annual ACM conference on Human factors in computing systems - CHI '14. 3757-3766. <http://dx.doi.org/10.1145/2556288.2557396>
- [44] L.J. Rogers. 2010. Relevance of Brain and Behavioural Lateralization to Animal Welfare. *Applied Animal Behaviour Science* 127, 1, 1-11.
- [45] L. Ruge, C. Mancini and R. Luck. Year. Requirements Engineering Elicitation for Mobility Assistance Dogs: Meeting Canine User Needs through Technology Enabled Interpretation. In Proceedings of 24th International Conference on Requirements Engineering: Foundation for Software Quality.
- [46] M. Siniscalchi, R. Sasso, A.M. Pepe, G. Vallortigara and A. Quaranta. 2010. Dogs Turn Left to Emotional Stimuli. *Behav Brain Res* 208, 2, 516-521. <http://dx.doi.org/10.1016/j.bbr.2009.12.042>
- [47] K. Svartberg and B. Forkman. 2002. Personality Traits in the Domestic Dog (*Canis Familiaris*). *Applied animal behaviour science* 79, 2, 133-155.
- [48] T. Travain, E.S. Colombo, L.C. Grandi, E. Heinzl, A. Pelosi, E.P. Previde and P. Valsecchi. 2016. How Good Is This Food? A Study on Dogs' Emotional Responses to a Potentially Pleasant Event Using Infrared Thermography. *Physiology & behaviour* 159, 80-87.
- [49] E. von Borell, J. Langbein, G. Després, S. Hansen, C. Leterrier, J. Marchant-Forde, R. Marchant-Forde, M. Minero, E. Mohr, A. Prunier and D. Valance. 2007. Heart Rate Variability as a Measure of Autonomic Regulation of Cardiac Activity for Assessing Stress and Welfare in Farm Animals a Review. *Physiology & Behavior* 92, 3, 293-316.
- [50] N. Walliman. 2011. *Research Methods: The Basics*. Routledge Oxon
- [51] D.L. Wells. 2003. Lateralised Behaviour in the Domestic Dog, *Canis Familiaris*. *Behavioural processes* 61, 1-2, 27-35.
- [52] F. Wemelsfelder. 1997. The Scientific Validity of Subjective Concepts in Animal Welfare. *Applied Animal Behavior Science* 53, 75-88.
- [53] F. Wemelsfelder, T.E.A. Hunter, M.T. Mendl and A.B. Lawrence. 2001. Assessing the ‘Whole Animal’: A Free Choice Profiling Approach. *Animal Behaviour* 62, 2, 209-220. <http://dx.doi.org/10.1006/anbe.2001.1741>
- [54] M. Westerlaken and S. Gualeni. 2014. Grounded Zoomorphism. In Proceedings of Proceedings of the 2014 Workshops on Advances in Computer Entertainment Conference - ACE '14 Workshops. 1-6. <http://dx.doi.org/10.1145/2693787.2693796>
- [55] A. Zamansky, D.v.d. Linden and S. Baskin. 2017. Pushing Boundaries of Re: Requirement Elicitation for Non-Human Users. In Proceedings of 2017 IEEE 25th International Requirements Engineering Conference (RE). 406-411. <http://dx.doi.org/10.1109/re.2017.30>