EXPLORING THE MEDIATING ROLE OF PLAYFUL TECHNOLOGICAL ARTEFACTS DESIGNED FOR ANIMALS AND HUMANS

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Abstract

In this thesis I investigate the mediating role of playful technological artefacts designed for animals and humans through theory and practice with the over-all aim to explore how we can design meaningful artefacts both for and with animals in order to better understand them and enrich or improve their lives.

Starting from Bruno Latour’s *Actor Network Theory*, which offers a valuable starting point for the inclusion of both humans and nonhumans as actors in a shared network that is constantly being made and remade, I suggest adopting a more informed form of inevitable anthropomorphism in interaction design with animals. Drawing from the work of Donna Haraway I argue for an approach in which we aim to experiment with actual situated design contexts through playful interactions. In this setting we can explore ‘becoming with’ as the worldly embodied interpretations of both human and animal and the meaningful bodily relationships that are developed within the course of the interactions that take place. Instead of focusing on animals and humans as users, as is often the case in ACI and HCI practices, I propose to visualise what happens between the actors, as the dynamic process of playful interaction unfolds.

Using the basic outlines of a programmatic research approach, I reflect upon a total of six prototypes that I have developed and tested. My aim is to visualise and reflect upon the dynamic relationships between the animal, human, and design artefact that can be observed within the course of the interaction. To build a design repertoire, these six artefacts are presented in the form of a design gallery in which the design concept and experiments are described for each artefact, supported with visualisations and explanations of the prototypes and testing.

Subsequently, I concretely visualise the notion of *becoming with* between animals, humans, and artefacts, and explore the relationships between the involved actors as the interaction unfolds through annotated videos in which I aim to visually map the interactions that can be observed. For each prototype, I reflect upon these annotated videos together with the involved designers with the aim to better understand the mediating role of the technological artefact that we designed. For the first four prototypes the reflection is focused on the *becoming with* of the humans and animals that participate in the interaction with the artefact with the goal to evaluate the design of the prototypes. The last two prototypes specifically focus on the reflection on *becoming with* the animal as a human designer during the design process.

Through visualising these dynamic interaction networks, the relationships between the animal, human, and artefact becomes more abstract and results in a better understanding of the mediating role of the technological artefact. Each prototype has major differences in the way the interaction network is visualised and the annotated videos show to be a valuable tool for the designer to discuss new design iterations that could be explored further.

The knowledge contributions and takeaways of this thesis project include a new theoretical argument, a method that can be used for the visualisation of the dynamic interaction networks as a tool for designers to better understand the relationships between animal, human and artefact, a design repertoire with six different prototypes, and the annotated videos as concrete takeaways that provide a deeper insight into the experimentation, testing, and reflections of the six different prototypes.
1. Introduction

"[...] if horses or oxen or lions had hands,
Or could draw with their hands and accomplish such works as men,
Horses would draw the figures of the gods as similar to horses,
And the oxen as similar to oxen,
And they would make the bodies of the sort which each of them had."

(Xenophanes of Colophon, 1992, p. 25)

This short fragment from Xenophanes emphasizes how our human perception of the world is often fundamentally focused on our human capabilities and illustrates how we usually design the world according to our perspective. As a result, our human ability to design and develop technology is also centrally concentrated around our human needs and understandings. I believe however, that we as human beings can also use our abilities to design and develop technology in order to understand and enrich the lives of other species. The animals that live in our society are to one extent bound to their own needs and behaviour. On the other hand, we, human beings, build artificial living environments for them in which they are required to adapt to the limitations, interactions, and technologies we create. Up until recently, a user-centred design approach automatically referred to a human target group, since it is difficult for human beings to understand the needs and preferences of animals while applying the same methods. To change this human centred perspective, I argue that it is both timely and necessary to open up for a new research area in interaction design in which we investigate how we can include the animal itself as a legitimate participant in the research and design process.

Because of the animal's sensory perceptions and its experience of the environment, the characteristics of technologies that the animal can independently and voluntarily interact with require different types of interfaces. These artefacts, such as interactive toys (Westerlaken and Gualeni, 2014b), cow-activated automatic milking systems (Rossing, W. et al., 1997), or communication devices for assistance dogs (Jackson et al., 2015) allow us to research how technological mediation can enrich or improve the lives of the animals that live in our society. Philosopher Peter-Paul Verbeek argues that users are not passively subjected to the technological mediation, but humans [and animals], and arguably even the technological artefact itself, have the ability to actively co-shape their mediated role in the course of the interaction (Verbeek, 2011, p. 8). Furthermore, technologies have no fixed identity; they are defined in their context of use and are always 'interpreted' and 'appropriated' by their users (Verbeek, 2011, p. 97). Therefore, the design processes should be equipped with the means to act in a desirable, morally justifiable, and democratic way (Verbeek, 2011, p.90). From this perspective, the aim for morally justifiable technological artefacts that actively mediate non-human users signals that the required methodologies for investigating and designing for animal-users might be radically different compared to the ones we apply for humans. In summary, what I aim to find out is: how can we design technologically mediated interactions, both for and with animals, with the goal to better understand them and enrich or improve their lives?
2. Related Work

We share our anthropic world with animals and we are already arguably affecting their lives with technology in many ways. Throughout the last century, animals have been involved in machine-driven interactions in a number of different contexts, such as agriculture, scientific research, the commercial domestic animal industry, military applications, et cetera. One of the first well-known examples includes Skinner’s experiments on animals using operant conditioning methodologies, among which the training of pigeons to peck at a target inside the nose of a missile in order to steer it in the desired direction (Skinner, 1960). Since then, technological advancements and the development of new interaction possibilities facilitated a number of research- and commercial projects aimed at establishing interactive relationships between animals and computers. During my thesis project in 2014 I have elaborated on several existing relevant projects and I categorized them according to three themes: animals influencing technical systems, technical systems influencing animals, and playful technical animal interactions (Westerlaken, 2014). A couple of examples:

**Animals influencing technical systems:** such as the training of Rhesus monkeys to control a joystick and respond to computer-generated targets (Washburn, Rulon and Gulledge, 2004) (figure 1) or a robotic system in which the bodily movements of a cockroach are translated into the physical locomotion of a three wheeled robot (Hertz, no date) (figure 2).

![Figure 1: rhesus monkey computer interface](image)

![Figure 2: cockroach robot](image)

**Technical systems influencing animals:** such as the use of artificial electrical stimulation to control the movements of cockroaches (Holzer and Shimoyama, 1997) (figure 3) or a human controlled plastic representation of a chicken that transforms its touches to a haptic jacket that the chicken is wearing and activates vibration motors to simulate a stroking sensation (Lee *et al.*, 2006) (figure 4).

![Figure 3: electrical stimulation of cockroaches](image)

![Figure 4: haptic vests for chickens](image)
**Playful technical animal interactions:** such as a game that allows humans and captive pigs to play together from distance (Driessen et al., 2014) (figure 5) or playful touch interfaces that can provide environment enrichment for captive orang-utans (Wirman, 2013) (figure 6).

These three themes outline different ways in which the roles of humans, animals, and technology can be divided. However, as discussed by Mancini (Mancini, 2011), and in my own work (Westerlaken and Gualeni, 2013), the design of systems that involve animals as users is often centred on human aspirations and perceptions, thus failing to include the animal as legitimate stakeholder in the design and research process. This becomes especially clear in examples in which the animal does not have much control over the technical mediation itself or its choice to participate, such as in the examples of figures 1, 2, 3, and 4. Yet, the public sphere is currently being redefined to a more holistic view on the relationship between people and our planet, which encourages a transformation in how we regard animals, how we communicate with them, and what place they take in the world. This transformation is largely supported by the design and use of new devices, interfaces, and interaction modalities.

In 2011, Animal-Computer Interaction (ACI) was introduced in the larger context of academic disciplines involved in Human-Computer Interaction (HCI) (Mancini, 2011). As a research field, ACI advocates for a user-centred approach informed by the best available knowledge of animals’ needs and preferences (Mancini, 2011). Nonetheless, this new field still lacks a tradition and a systematic organization of methodologies and theories.

A significant amount of existing research is currently situated within the field of ACI and its emerging research community. Over the last years, several publications have been release at conferences such as CHI (Väätäjä and Pesonen, 2013) and UbiComp (Mancini et al., 2012), and in workshops specifically dedicated to ACI such as NordiCHI (Westerlaken and Camilleri, 2014), and ACE (Westerlaken and Gualeni, 2014b). However, I do not think that the design of technologically mediated interactions for animals should be situated and limited to an HCI based approach. I believe that other research fields and communities such as Animal Studies, Philosophy, and Interaction Design Research are both valuable and necessary in relation to this topic and the emerging ACI community should be open to approaches that stem from these fields and might use different methodologies than those that are considered standard for HCI research. Rather than situating my research around the field of ACI I will therefore refer to my work as Technologically Mediated Human-Animal Interaction.
3. Research Focus

With this research I wish to produce design knowledge that continues my previous work in this area and contributes to the discussion regarding the design and evaluation of physical interfaces and artefacts that facilitate meaningful interactions with animals and humans. The so called ‘big question’ that I aim to explore with my work is:

*How can we design technologically mediated interactions, both for and with animals and humans, with the goal to better understand them and enrich or improve their lives?*

This main question suggests us to turn to the design process and find methodologies that can help us as designers to understand the mediating role of the artefacts that we design and reflect upon the experiences and perceptions of our human and nonhuman users. The objective of this thesis project therefore includes a focus on existing design practices and finding new tools to incorporate in design and evaluation processes that include animals. Following up on the examples of technologically mediated human-animal interaction I mentioned in the previous chapter, it becomes clear that the mediating roles of the technology as well as the roles for the human and the animal are not simple and straightforward. These projects show multiple different ways in which the interaction is shaped by the different actors that are involved. This tremendously changes the participant’s engagement and possibilities to interact for both the human and the animal. When we want to include animals in technologically mediated interactions as well, we will need to think about the moral consequences of this and develop new ways of thinking about technological mediation. In order to investigate this mediating role further and analyse how reflecting upon this can be valuable for the design process, I will include theoretical work of two main authors: Bruno Latour, and Donna Haraway.

In his work, specifically in his *Actor Network Theory*, Latour understands reality in terms of networks of agents that interact in manifold ways, continually translating each other (Latour, 2007). Important is that these agents can be both human and nonhuman and help to shape each other (Latour, 2007). By looking further into this theory I aim to find ways in which we can introduce animals as a specific type of actors that, rather than being merely included as a nonhuman element, can be seen as a legitimate stakeholder that can obtain a space next to the human in the course of the interaction.

Haraway’s work, *When Species Meet*, centres on this importance of including the nonhuman other and focuses on need to do the work of thinking and remaking encounters in actual, situated contexts, as opposed to philosophizing in the abstract (Haraway, 2008). It is only in this way, Haraway argues, that we might be able to *become with* and recognize, respond and encounter respectful relationships with non-human others (Haraway, 2008). She furthermore writes about the activity of ‘play’ and ‘touch’ as specifically suitable activities in which these relationships can be explored, a thought that I would like to support and demonstrate with specific design examples in my work.

In this thesis, I will use the work of Latour and Haraway to argue for a theoretical framework that we can use to include our users in the design process of artefacts that have both human and animal participants. Subsequently, I will apply this theory to a total of six design prototypes that invite playful interaction between humans and animals with the aim to reflect upon the dynamic
relationships between animal, human, and technological artefact that can be observed during the interaction. By doing this I aim to contribute theoretical knowledge by exploring the mediating role of playful technological artefacts designed for humans and animals and demonstrate how they can shape the interaction between the participants in different ways. Furthermore, by sharing a design gallery with six different prototypes (two of these are developed within the timeframe of this thesis) including an elaboration on their development, I aim to contribute practical design knowledge by adding a design repertoire to a new research and design field.

Ethical considerations

Most of the prototypes that I include in this thesis have a focus on designing playful interactions for domestic dogs, I chose to focus on these animals because of the challenge to design interactions for animals with little attraction to visual elements (such as digital screens or 2D graphical interfaces). This allows me to explore the design of interaction for these animals with a focus on their strongest sensory perspectives (such as auditory and olfactory based interfaces). Moreover, this focus on dogs enables me to include my own two dogs in the testing phases of the research, which allows me to monitor their behaviour towards the technological artefacts continuously and it becomes more realistic to do many rapid prototype tests and experimentation within the timeframe of this ten week thesis project.

Next to the focus on dogs, there are a few other secondary elements that are important for me to obtain my research goals. These include that the research needs to be conducted by following standard ethical guidelines for including animals in HCI research (Vääntäjä and Pesonen, 2013). Secondly, the approach must regard the animal users as legitimate stakeholders and design contributors and must be informed by the best available knowledge of the animal’s needs and preferences. And third, the research focus generally needs to adhere to my aim to enrich the animal’s life or improve animal welfare either in a direct or indirect manner. Within the context of this thesis project, my focus will be on the design and development of playful interaction between me and my own dogs. Therefore, rather than designing for a specific (welfare related) problem, the context of this thesis is much more related to exploring the possibilities of playful interaction to enrich the daily life of domesticated animals. Nevertheless, my aim is to continue this research and the methodologies that emerge from it towards different contexts that may address new openings for design in the future.
4. Theoretical Framework

‘Loving our abstractions seems to me really important; understanding that they break down even as we lovingly craft them is part of response-ability. Abstractions, which require our best calculations, mathematics, reasons, are built in order to be able to break down so that richer and more responsive invention, speculation, and proposing—worlding—can go on’ (Haraway, 2008, p. 93).

Humans and animals are tangled and meet mostly in the mundane surroundings of everyday life. According to Haraway, this is where practical reworlding in concrete and practical situations can occur (Haraway, 2008, p. 93). Despite this, abstractions remain important, because this is the space in which we can speculate, reimagine, and remain open to become with those with who we are not yet (Haraway, 2008, p. 93). In this chapter I will attempt to convincingly argue a theoretical framework in which we can ground our experimental design work and create a design space in which both humans and animals can participate.

I will first provide a short introduction to Latour’s Actor Network Theory (ANT), which offers a valuable starting point for the inclusion of both humans and nonhumans as actors in a shared network that is constantly being made and remade. All actors are actively shaping and mediating their role in the interaction with each other and the environment. However, even though this theory aims to abandon human-centred thinking, applying this theory to design with humans as users and designers means that a distinct focus remains centred on the experience and reflections of human beings (Chapter 4.1). In order to start thinking beyond the human, I therefore argue for adopting a more informed form of inevitable anthropomorphism in interaction design with animals, drawing from the work of Haraway, in which we aim to experiment with actual situated design contexts through playful interactions (Chapter 4.2). In this setting we can explore ‘becoming with’ as the worldly embodied interpretations of both (human) designer and animal and the meaningful bodily relationships that are developed within the course of the interactions that take place. Instead of focusing on animals and humans as users, as is often the case in ACI and HCI practices, I propose to investigate what happens between the actors, as the playful interaction unfolds (Chapter 4.3). In practice, this is a dynamic process in which groups and networks are constantly shifting and evolving. I aim to demonstrate how this reflection can be helpful for designers by analysing a series of prototypes and visualizing the different actors and networks that can be observed through annotated videos of the participants’ interaction and reflecting on the results (Chapter 4.4).

4.1 TECHNOLOGICALLY MEDIATED ACTORS

One of the first issues that comes to mind regarding the research question of this project is our human capability to design for the nonhuman being. Our differences in perception and experience of the environment in which we live cause us to question how we can ever sufficiently understand the animal and start making design choices that can actually benefit them. With this challenge in mind, the moral implications for multi-species design suggests that it is the responsibility of the designer to meaningfully shape the actions and experiences of both the humans and the nonhumans that are involved in the interaction.
Latour's *Actor Network Theory* considers both human and nonhuman elements equally as actors that can be mapped within a network. In this network, everything is constantly in the making and depending on each other in dynamic relations between culture and nature, humans and nonhumans, or society and science (Latour, 2007). Following Heidegger, he argues that rather than a distinct split between subjects and objects we should aim to move beyond human-centeredness or encountering single objects, and instead adopt a worldview that regards *matters of concern* (rather than *matters of fact*) as socio-material assemblies of humans and nonhuman elements that do not exist in a vacuum, but are always intertwined in each other (Callon, 1986, p. 4). These so called *things* connect us not because they are factually true, but because they embody a shared involvement that includes all viewpoints that are related to it (Latour and Weibel, 2005).

For example, when I am playing together with my dog, we may interact with a specific dog toy. But for us to decide that a certain object will function as a toy in that moment, we both follow specific ways to act that are prescribed by the object and the context in which we find ourselves. I might grab and squeak a rubber toy to get the attention of the dog and throw it into the air. My dog might fetch the toy and bite in it and cause the toy to squeak. If we are playing in a forest on a sunny day, one of us might decide to pick up a branch and start playing with it, which prescribes a temporary semiotic label ‘toy’ to that specific object, until we leave it behind, move along, and end the play session. In these examples, we are mediated by the artefact (a toy that suggests certain affordances), the context (our mutual play session), our surroundings (a forest and the nice weather), and the way in which we both act in it. All these elements together form a network that co-shapes our actions and experiences and connects us to each other. If one of these actors changes its temporary composition, for example when I get distracted by my phone ringing and stop squeaking the rubber toy, or when it starts raining and the branches of the forest are getting wet, our actions and experiences might change which results in a changing assembly of the network that is co-shaped.

Drawing from the work of Latour, Peter-Paul Verbeek argues that participants are not passively subjected to the technological mediation but users, and arguably even the technological artefact itself, have the ability to *actively* co-shape their mediated role in the course of the interaction (Verbeek, 2011, p. 46). As we see in the example of playing together with a dog, artefacts (such as toys) have no fixed identity; they are defined in their context of use and are always ‘interpreted’ and ‘appropriated’ by their users (Verbeek, 2011, p. 97). In the context of design, we could say that the envisioned use of a design artefact is hardly the same as actual use and both immediate and future users will appreciate and appropriate designed artefacts in totally unforeseen ways (Binder *et al.*, 2011, p. 170). Therefore, as designers, we should aim to equip our design processes with the means to allow our users to appropriate our artefacts in a desirable, morally justifiable, and democratic way (Verbeek, 2011, p. 90).

Both Latour and Verbeek provide valuable starting points for the reflection on the design of interactions that involve animals as participants. Yet, even though in his work Verbeek writes about human users and nonhuman objects, and Latour speaks of both human and nonhuman actors, they both include a distinct focus on the humans that eventually interpret and appropriate the interactions. Latour writes how artefacts are not simply used by humans, but help to constitute humans, and their actions are the result not only of individual intentions in which human beings find themselves, but also of people’s material environment (Latour and Venn, 2002, p. 252). And Verbeek writes how human intentionality is mediated by technology.
and shapes a relation between human beings and the world (Verbeek, 2011, p. 46). Within the purpose of their work, it seems to be quite straightforward that their theories proposes the inclusion of nonhuman actors, only in order to then gain a better understanding of how human beings mediate and are mediated. So, even though their aim is to abandon human-centred thinking, the reflections of these philosophers naturally bring the eventual use of technology back in the hands of the human. This means that in their theories, the animal is not necessarily required to be represented by actual animal-spokesmen (Callon, 1986) in the design process. However, I argue that if we want to consider the animal as a legitimate stakeholder in the interaction, this division does not make animals and humans equal participants.

The consequences of this framework become clear, for example, in the work of Lenskjold and Jönsson. In her PhD dissertation, Jönsson provides a substantial account of Latour’s ANT and how their work is built upon this theory and aims to propose a non-anthropocentric design approach (Jönsson, 2014). In a paper derived from this dissertation, Lenskjold and Jönsson investigate the possibility of a pluralisation of perspectives in design by insisting on placing human and animal actors as equally capable of action and aim to expand the horizon of how and whom we design with and include into the design process (Lenskjold and Jönsson, 2014, p. 1). The authors convincingly do this with three different design experiments that explore the relationships between inhabitants of a retirement home and urban birds (such as gulls and magpies). Their design interventions are aimed at the deployment of speculative prototypes that could actualise new interspecies relations and are structured by methods and tools from co-design (Lenskjold and Jönsson, 2014, p. 5). They explicitly argue that their approach is different from ACI methods that simply substitute human users for animals, which continues the central mechanisms of a teleological design protocol, albeit now with a new series of challenges pertaining to difficulties in gaining access to the requirements seen from an animal perspective (Lenskjold and Jönsson, 2014, p. 2). The approach of Lenskjold and Jönsson shows to be both more holistic and experimental, by following theories of Latour and Haraway. However, even though their work provides a valuable new step in the realm of interaction design in which animals are invited as equal participants, their approach continues to have a distinct unequal focus on the co-design and reflections methods of the human beings that are involved in the interactions. The experience of the animal is never structurally reflected upon or taken into account when it comes to making design decisions. Perhaps limited through language and other human constrains, the authors rely on workshops and interviews with the human participants during the design process.

I think that if we want to open up for design challenges that invite animals as actual participants in the design process and if we want to design technologies that can become truly meaningful to them, instead of trying to avoid the inevitable anthropomorphism that we encounter as human designers making the eventual design decisions, we need to find ways in which we can start reflecting upon the relationships between animals, humans, and the artefacts that we design in a more informed manner. Building upon the work of Latour, I argue that if technologies can be considered mediators that actively help to shape realities, they cannot only constitute humans, but animals as well.
Throughout time, the design and development of technological artefacts has generally been dominated by human beings. According to broadly recognized theory on the evolution of the *Homo Sapiens*, the development of tools and technology has often been seen as the starting point of our human divergence from apes (De Mul, 2014). Nevertheless, over the last decades we discovered that the animal kingdom is also rich with tools and technological inventions used by animals such as chimps using branches to fish, crows that modify leaves to extract grubs from tree holes, and dolphins carrying sponges to protect their sensitive beaks while digging in the bottom of the ocean (Seed and Byrne, 2010). These discoveries suggest that humans are not the only species that can use and develop tools and, depending on our definitions of design and development, can open up for the question if it is possible to co-design artefacts together with animals.

Even though this would be an interesting discourse to explore further, in this project I will solely focus on the human as a designer and the animal as a valuable participant in the design process. This means that the design decisions are eventually made by a human, which entails an inevitable degree of anthropomorphism in which the designer has to translate her understanding of the animal experience to a design intervention or artefact that can then be experimented with through iterative processes including prototyping and testing with the animal. Rather than trying to avoid anthropomorphic thinking, instead I propose to include more informed forms of thinking beyond the human. To do this I will largely draw from the work of Haraway, in which I argue for experimenting with actual situated design contexts through playful interactions.

In her book, *When Species Meet*, Haraway suggests that we should take seriously the relationships between humans and animals and the ultimately unbridgeable human/nonhuman divide, since our choices have consequences and demand respect and response, rather than an impossible attempt at rising to a sublime and final end that explains our differences (Haraway, 2008, p. 15). She writes that insofar human beings and machines use animals, we are used by the animals as well, because we are always already entangled together by being in the world. 'The animals make demands on the humans and their technologies to precisely the same degree that the humans make demands on the animals' (Haraway, 2008, p. 263). This makes us companion species by default, which means that we have ethical obligations to the animal:

'My point is simple: Once again we are in a knot of species coshaping one another in layers of reciprocating complexity all the way down. Response and respect are possible only in those knots, with actual animals and people looking back at each other, sticky with all their muddled histories. Appreciation of the complexity is, of course, invited. But more is required too. Figuring what that more might be is the work of situated companion species' (Haraway, 2008, p. 42).

In order to become more responsive and respective towards our interaction with animals, Haraway argues for actual encounters with animals in practical situated contexts, face to face with the animal. It is only in this way that we can 'become with' and recognize, respond, and strike up respectful relationships with nonhuman others (Haraway, 2008, p. 63). Throughout her book, Haraway mainly focuses on two ways through which these practical encounters of
becoming with can take place: touch and play. The first element, touch, is an encounter that shapes accountability:

'My premise is that touch ramifies and shapes accountability. Accountability, caring for, being affected, and entering into responsibility are not ethical abstractions; these mundane, prosaic things are the result of having truck with each other. Touch does not make one small; it peppers its partners with attachment sites for world making. Touch, regard, looking back, becoming with—all these make us responsible in unpredictable ways for which worlds take shape' (Haraway, 2008, p. 36).

The second element that Haraway considers to be specifically suitable for remaking actual encounters between humans and animals includes the activity of play, because it can open up for degrees of freedom and new possibilities:

'[J]oy is something we taste, not something we know denotatively or use instrumentally. Play makes an opening. Play proposes. The taste of “becoming with” in play lures its apprentice stoics of both species back into the open of a vivid sensory present' (Haraway, 2008, p. 240).

I think that in the field of Interaction Design, these two elements, play and touch, open up for particularly interesting and inspiring design spaces for meaningful encounters between humans and animals. In my previous work I have suggested how play forms a specifically suitable context in which a mutual understanding between humans and animals is already naturally present due to shared interactions and responses to bodily cues (Westerlaken and Gualeni, 2013). Taken together with the element of touch proposed by Haraway, I suggest that, rather than solely focusing on designing for a formal invitation to play, we could embrace the design of artefacts that invite ‘playfulness’.

In his book Play Matters, Miguel Sicart writes about play as a portable tool for being that is not tied to objects but brought together to the complex interrelations with and between things that form daily life (Sicart, 2014, p. 2). He argues that play is not necessarily the ludic, harmless, and positive activity that has been described by philosophers, but it can also be destructive, serious, or chaotic. According to Sicart, playful designs are by definition ambiguous, self-effacing and in need of someone to complete and interpret them. Rather than design centred thinking, playful design opens up for a conversation among participants, designer, context, and purpose (Sicart, 2014, p. 31). This means that playful technologies do not necessarily have to be limited to toys or games, but can also include interventions that open up for respectful and meaningful conversations between human and animal in other ways. For example through the exchange of affection or reward, using different senses to explore objects out of curiosity, providing pleasurable cognitive challenges, walking together, doing sports together, or simply looking at each other. It is the process of design in which humans and animals can start to ‘become with’ and create meaning through playful encounters.
4.3 BECOMING WITH THE ANIMAL AS A DESIGNER

Drawing from the ANT of Latour, Haraway’s notion of *becoming with* animals in actual situated contexts, and Sicart’s understanding of designing for playful interaction, I suggest that a valuable step in the design process is to explore the notion of *becoming with* as a designer through actual prototyping and experimenting in playful interaction contexts. But what does it mean to *become with* and how can we participate in this as designers?

Haraway describes the notion of *becoming with* as the subject- and object-shaping dance that takes place when companion and species are knotted together in encounters with regard, response, and respect (Haraway, 2008, p. 4). In her book, she describes many examples of contexts in which this mutual encounter takes place, such as when she is doing agility sports with her dog Cayenne and they both respond to each other’s cues and behaviour, or when herding dogs get in the so called contact zone and *become with* both the sheep and their human handlers to successfully guide the sheep in the desired direction. Other authors have proposed notions that are similar to *becoming with* but are grounded in different theoretical frameworks. In his work, philosopher Jos De Mul analyses hermeneutical concepts regarding understanding and interpretation of organic life by reflecting upon theories of Dilthey and Plessner (De Mul, 2013). He uses the term *going-along* to describe the mutual understanding between humans and animals by giving the example of himself playing with his dog:

> ‘The ritual generally went as follows. The dog put the rope toy before my feet, so that I could grab it, but as soon as I tried to do so, it tried to snatch it away. When the dog succeeded, the rope toy was put before my feet again, and when I was quicker, I was supposed to throw the rope toy away, after which the dog retrieved it and the game would start anew, and would continue until either the dog or I got tired of it’ (De Mul, 2013, para. 3).

What characterizes this experience, is that the purpose of the interaction is not ascribed a priori, but unfolds itself in the course of the bodily interaction (De Mul, 2013). He suggests that the mutual understanding between humans and animals is depending on the extent to which we can *go along* in a common embodied praxis such as play (De Mul, 2013).

In a different context, authors from the ACI group at the Open University U.K. have taken an approach that is derived from Peirce’s theory of semiotics by describing how one of the three kinds of communication signs (‘symbols’, ‘icons’, and ‘indices’) can be specifically useful for interactions between humans and animals: where ‘symbols’ and ‘icons’ are understood as abstract signs that require linguistic abilities, ‘indices’ are instead directly and physically grounded in a bodily relationship with the world and other beings and therefore neither preclude nor require shared mental abilities (Mancini et al., 2012). For example, one of my own dogs has its own conceptual understanding of the meaning when I use my index finger to point to a specific object and she looks directly at the direction in which I am pointing. The other way around, I understand the way in which my dog points me to specific objects by continuously switching eye contact or movement between me and an object (such as a toy or an empty food bowl). On this basis, the authors propose that humans and animals can *co-evolve* by interpreting the each other’s semiotic processes on the level of understanding their indexical signs and then connect meaning to them in the context of human-animal interaction (Mancini et al., 2012).
Between humans, we often use language for understanding each other and we participate in what philosopher Ludwig Wittgenstein calls *language games*: the communication between participants that allows us to express and enact experiences beyond words (Binder et al., 2011, p. 163). Wittgenstein explains how participation in a language game is a kind of rule-following social behaviour in which the rules are not made explicit and formulated a priori, but they are made up and altered as we play along (Binder et al., 2011, p. 163). To follow these rules is to embody them and to act in a way that other can understand the game that is played (Ehn, 1989, p. 106). This happens not only through words, but also through gestures, body signals, and experiences. As an example, Wittgenstein asks us to explain how a clarinet sounds (Ehn, 1989, p. 113). Through this example it becomes clear that for two beings to have a similar understanding of the sound of a clarinet, they must have both heard the sound of this instrument to have the practical sensuous understanding of the experience of listening to a clarinet. This does not only apply to humans: if both me and my dog listen to the sound of a clarinet, we both experienced the practical understanding of this activity and we share a certain family resemblance (Wittgenstein, 1973, p. 32) to it without the need of explaining it to each other in words. However, our sensory perception, such as the difference in hearing capacity between dogs and humans, might have caused us to understand it in a different subjective sense. So even though we cannot rely on expression and communication through language with animals (this is also touched upon by Wittgenstein in his quote 'if a lion could talk, we could not understand him' (Wittgenstein, 1973, p. 223), referring to the difference in life form between humans and lions), the concept of a *shared language games* can still be practiced, albeit in a different sense (Ehn, 1989, p. 118), namely through practical understandings, shared experiences, gestures, etc. In design, the notion of shared *language games* between users and designers provides the opening for design in which both designers and users can participate (Binder et al., 2011, p. 163). According to Ehn:

‘[U]sers and designers do not really have to understand each other in playing language-games of design-by-doing together. Participation in a language-game of design and the use of design artifacts can make constructive but different sense, to users and designers. (...) As long as the language-game of design is not a nonsense activity to any participant, but a shared activity for better understanding and good design, mutual understanding is desired but not really required.’ (Ehn, 1989, p. 118).

This aspect is particularly useful in the context of participatory design that I am aiming at in this thesis, by inviting both the human and the animal to become legitimate participants in the design process. Through constructive shared *language games* in design experiments in which the human and the animal can understand each other in a different sense, beyond the use of language, we can explore different scenarios, contexts, and prototypes together in order to come to new meaningful designs.

Looking at the definitions of these different terms, *becoming with*, *going-along*, *co-evolving*, and *language games* it becomes clear that even though they are grounded in different theories, they can all serve a similar purpose: providing a conceptual framework for the immediate and bodily understanding that takes place between humans and animals when they encounter each other face to face. Within the context of this thesis, I will focus on Haraway’s notion of *becoming with*, because of the detailed account of the term in her books and papers and her theoretical grounding in the work of Latour that I also embrace in this thesis.
One particularly interesting example of *becoming with* that Haraway explains includes the work of bioanthropologist Barbera Smuts in her PhD study in which she observed wild baboons in Kenya. Trained according to the conventions of scientific objectivity she was advised to be as neutral as possible while studying the animals, behave like a rock, and be unavailable, so that the baboons would act naturally and could be observed objectively (Haraway, 2008, p. 23). She soon noticed that the baboons were unimpressed by her rock act and frequently looked at her and were unsatisfied with her ignoring them (Haraway, 2008, p. 24). She discovered that ignoring social cues is in fact far from social behaviour and she began to adjust herself:

I ... in the process of gaining their trust, changed almost everything about me, including the way I walked and sat, the way I held my body, and the way I used my eyes and voice. I was learning a whole new way of being in the world—the way of the baboon. ... I was responding to the cues the baboons used to indicate their emotions, motivations and intentions to one another, and I was gradually learning to send such signals back to them. As a result, instead of avoiding me when I got too close, they started giving me very deliberate dirty looks, which made me move away. This may sound like a small shift, but in fact it signaled a profound change from being treated like an object that elicited a unilateral response (avoidable), to being recognized as a subject with whom they could communicate’ (Smuts, 2001, p. 295).

I am highlighting this particular example of Smuts’ attempt to *become with* the baboons she studies, because I think that the way in which she facilitates the interaction with the animals can provide an interesting starting point for us to *become with* as interaction designers while exploring the design space. Rather than merely observing the animals and their interaction with artefacts from distance, we can take part in the playful interaction as human beings as well and explore the possibilities together as a form of co-designing. Where the participatory design tradition already includes the involvement of the human participants with the use of *shared language games* (Binder et al., 2011, p. 163), I suggest that through the concept of *becoming with* we can include the animal participant in the design process as well.

To start taking an attempt at *becoming with* as designers, we can open up for a conversation between the material, the animal, and the human by working out design scenarios face-to-face with all the participants involved, using techniques such as bodystorming (Schleicher, Jones and Kachur, 2010) and experimenting with prototypes and iterations in concrete design contexts. While applying these methods, rather than scientifically analysing the animal or human behaviour and treating them as individual users with specific characteristics and generalized user-experiences as is often the case in ACI and HCI practices (Gaver, 2012), we should focus on what happens *between* different actors in a specific design context, how relationships are constantly made and remade within the network that unfolds itself through the interaction, how the humans and animals respond to each other, and what role the designed artefacts play in each set-up. These efforts initiate a way to better understand the mediating role of the technology we design and how concepts that open up for responses, mutual understandings, and conversations between human and animal can be explored with different kind of artefacts. Through the design and experimentation with actual working prototypes I aim to reflect upon the role of the design and how relationships between human, animal, and artefact are evolving during the playful interactions. I argue that this is both a valuable and necessary step in the approach of design with nonhumans and it helps to investigate more appropriate forms of anthropomorphism that we should aim to include in design and evaluation processes that invite animals to participate.
4.4 DYNAMIC INTERACTION NETWORKS

In practice, when we start looking at existing examples of playful technologically mediated human-animal interactions, we can start to observe that the relationships between animals, humans, and technological artefacts are all constituted in different ways. To outline these differences I will briefly visualize four different instances in which interaction networks are formed and humans and animals are showing traits of becoming with through the mediation of technological artefacts. In my attempt to visualise these instances of interaction networks I focused on the main three actors (animal, human, and artefact) and mapped out their relationship to each other. In the following diagrams, I visualised the power dynamics (the size and height of the circles compared to the others) and their interaction with each other (the amount of overlap between different actors). The examples include a cat and human playing with a laser pointer, a dog and human playing with a rope toy, a dolphin and human doing a training exercise with a hoop, and a horse and human jumping over a pole:

<table>
<thead>
<tr>
<th>Interaction Instance</th>
<th>Interaction Description</th>
<th>Interaction Network</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Interaction Image" /></td>
<td>In this image, a cat (A) and human (H) are playing with a laser pointer (X). The human is in control of the artefact, pointing it from above, and the cat responds to the human's movement of the light. The cat is focused on the artefact.</td>
<td><img src="network1.png" alt="Interaction Network" /></td>
</tr>
<tr>
<td><img src="image2.jpg" alt="Interaction Image" /></td>
<td>Here, a dog and human are playing together with a rope toy. They both hold on to the toy and they make eye contact with each other. The human has lowered his body to almost the same height as the dog.</td>
<td><img src="network2.png" alt="Interaction Network" /></td>
</tr>
<tr>
<td><img src="image3.jpg" alt="Interaction Image" /></td>
<td>In this example, a dolphin and human are interacting in the form of a training exercise with a hoop. The human holds on to the artefact and looks at the dolphin. The dolphin possibly decides to jump through when the human gave a cue in order to get a reward.</td>
<td><img src="network3.png" alt="Interaction Network" /></td>
</tr>
</tbody>
</table>
This image shows a horse and a human jumping over a pole. The human is using technological equipment (halsters, reins, stirrups, etc.) and body language to steer the horse in certain directions. The horse and human both look in the same direction.

From these examples, it becomes visible that for each interaction instance, the relationship between animal, human, and artefact is shaped in a different way. I would argue that this also changes the extent to which the animal and human are becoming with and enter in a state of mutual understanding as the interaction unfolds. For example, the interaction between the cat and the human, is characterised by a top-down structure of play in which the cat is not necessarily aware of the fact that she is playing with a human being. For the dog and human on the other hand, the artefact brings them closer together and facilitates playful interaction on a much more equal level, where the dog and human make eye contact, show similar bodily behaviour, and respond to each other’s movements and signals. The interaction of the dolphin and the human is mostly structured in the form of a playful training exercise in which the artefact serves as a tool that, through its affordances, opens up for interaction that is driven by the human and responded to by the animal. In case of the horse and the human, the equipment forms an extension of the human body that allows for detailed embodied communication between horse and human. This instance is characterised by very focused and connected interaction that is enforced by the design of the artefacts.

For designers of technology that mediates the relationships between humans and animals, these visualisations of interaction networks can form interesting and valuable tools for getting a better understanding of the interaction that unfolds between animal, human, and artefact. This can be useful for designers at different stages in the project, such as during the iterative design process itself and as a reflection on the design artefact. In the examples above, I have visualised the networks of four different single instances that show different types of interaction. However, in reality, these networks are structured through dynamic processes that are constantly changing, evolving, breaking apart, and coming together. For example, in case of the interaction between the dog, human, and rope toy, the dog might have initiated the play session first on her own by bringing the toy to the human. Or perhaps the dog might get distracted when another dog walks by. Or maybe the human starts playing too rough and the dog loses her interest in continuing the play session. This means that if we want to get a better understanding of the mediating role of an artefact in a design process, rather than looking at a single instance of the interaction, we should analyse the unfolding of relationships between participants for a longer period of time. Therefore, rather than looking at static images, I propose to make use of video recordings of the interactions with participants and artefacts and complement these with animations of the interaction networks that can be observed in order to underline the constant making and remaking of our encounters.
Analysing the interaction networks between artefact and participants can give us new information about the way in which the interaction is composed, how it develops, and how it ends. Depending on the intentions of the designer, this information can then lead to new design iterations that address potential challenges in different ways and can change the way the interaction unfolds. I argue that, rather than looking at different users separately, these types of reflections can allow us to look at the relationships between participants and help designers to explore notions of becoming with in our own design processes to start developing a better understanding of the mediating role of the artefacts that we intent to design.

As a summary, in this chapter I have argued for a theoretical framework that we can use in the design process of artefacts that have both human and animal participants. Starting from the work of Latour, I suggested to include both humans and nonhumans as actively mediating actors in a shared network that is constantly being made and remade. Haraway’s work then formed the basic outline for adopting more informed form of anthropomorphism in interaction design with animals aimed at experimenting with concrete design contexts through playful interactions. In order to explore the notion of becoming with between animals, humans, and artefacts, I propose to explore the relationships between the involved actors as the interaction unfolds. These dynamic processes can be analysed through visualisations of the networks through annotated videos of the interactions. These reflections can provide valuable information for designers to better understand the mediating role of technological artefacts and the ways in which the interaction is composed, how it develops, and how it ends.

In the remaining chapters of this thesis, I will give a more detailed account of how we can approach these animated visualisations of dynamic interaction networks and use them both during the design process itself and to reflect upon a design artefact, by applying this method to six different prototypes that I developed over the past two years that invite playful interactions between humans and animals.
5. Methodology

In this chapter I will outline the methodological approach I take in this thesis project. First, I provide an overview of existing methods in the field of technologically mediated human-animal interactions and suggest the opportunities for expanding this framework. Second, I explain the values of a programmatic research approach within the context of this work. And third, I outline the methods that I adopt in the remaining of this thesis project.

5.1 Establishing New Methods

Even though the research field of ACI is still exploratory, a few methodological approaches to the design and research of technologically mediated human-animal interactions have been presented over the last few years. These include insights coming from a variety of disciplines and perspectives including approaches related to Ethnography, Semiotics, Digitally-Complemented Zoomorphism, and Grounded Theory. In a previous publication (Westerlaken and Gualeni, 2014b), I summed up these methods roughly as follows:

**Ethnography and Semiotics**

In 2011, Weilenmann and Juhlin argued that research in the field of ACI could be significantly enhanced by the adoption of an ethnomethodological perspective (Weilenmann and Juhlin, 2011). The authors write that since we cannot avoid human subjectivity in understanding the behaviour of animals, we could resort to a more sophisticated form of anthropomorphism by trying to include the understanding of the natural habitat and behaviour of the animals in our assessment of their interaction with computers. Using this ethnographical study as an example, Mancini et al. later wrote that even though the approach of Weilenmann and Juhlin focused on the immediate context of the interaction, the interaction itself might be defined by a broader relational context, which includes both the animal and the human (Mancini et al., 2012). They expanded this ethnomethodological framework with the theory on Semiotics that I outlined in Chapter 4.3 of this thesis in which the exchange of indexical signs (such as posture, movement, alert calls, smells, etc.) constitutes the basis for the understanding of the relationships between animals, humans and technology (Mancini et al., 2012).

**Digitally Complemented Zoomorphism and Grounded Theory**

Based on the understanding of ‘play’ as a free and voluntary activity, Westerlaken and Gualeni argued for a more informed form of anthropomorphism that can be applied to technologically mediated human-animal interaction and relocates the focus from the human perspective to the animals’. From this framework, the following three guidelines emerged:

1. It recommends the use of external stimuli in the form of technological artefacts: the natural curiosity of animals and their explorative behaviour can be used to stimulate their engagement with interactive technological artefacts in a research setting. This means that the animal is motivated by the artefact to engage in natural and voluntary interaction;
2. It analyses animal behaviour through ‘going along’ in a common praxis: the understanding of indexical semiotics and common traits in the way bodily signals are
produced and interpreted allows specific species to understand others to a certain degree. This ‘going along’ could be achieved in a common and free praxis such as play. This objective unfolds itself intuitively in the course of the interaction;

3. It advises to digitally track metric and/or biometric data concerning the animal experience: In order to complement the subjective human approach that results from the first two guidelines, metric and/or biometric research can offer additional insights in the experiences of the animals that are studied. This includes methods that can provide a quantifiable analysis of the interaction with the artefact.’ (Westerlaken and Gualeni, 2013)

Subsequently, as an additional method for getting a better understanding of the animal’s experience during the interaction with technological artefacts, a Grounded Theory (GT) approach could be followed. In GT, rather than performing data analysis starting from hypotheses and preconceptions, the data itself guides the analysis and steers the research in directions that were not planned out from its onset (Westerlaken and Gualeni, 2014b). The GT method typically includes the collection of data through interviews or video observations which are then examined and coded with the objective of identifying patterns and their interrelationships (Furniss, Blandford and Curzon, 2011). GT was adopted with the objective to re-balance the design process of digital toys towards the inclusion of the animals that are supposed to be the final users (Westerlaken and Gualeni, 2014a).

The theoretical framework that was outlined in Chapter 4 of this document forms the basic outline for an extension of this methodological approach in which both humans and nonhumans are included in the design process as actively mediating actors in a shared network. In order to further explore these dynamic networks in concrete design contexts through playful interactions I argue for an extension that is derived from Digitally Complemented Zoomorphism in the sense that it advocates for structurally exploring the notion of becoming with or going along through voluntary interaction with external stimuli in the form of technological artefacts. Furthermore, it suggests to expand the GT approach by visualising the dynamic interaction networks through video observations that can then be reflected upon to uncover patterns regarding the mediating role of technological artefacts and the ways in which the interaction is composed, how it develops, and how it ends.

5.2 PROGRAMMATIC RESEARCH

Another element derived from the theoretical framework in Chapter 4 of this document is the need for experimentation in actual concrete design contexts where the animal and human can meet face to face. According to Löwgren, Larsen, and Hobye, the field of Interaction Design is always about the whole context of use, where artefacts are always embedded in practices and the designer always needs to address the whole (Löwgren, Larsen and Hobye, 2013). In the early 2000’s, Johan Redström introduced the notion of programmatic design research in order to conceptualize research that turns the characteristics of design into strengths (Löwgren, Larsen and Hobye, 2013). A programmatic research approach in design typically consists of multiple design experiments that are reflected upon (Hobye, 2014) and consists out of three iterative steps that are deeply interwove: the formulation of a program, the realization of this program through multiple experiments, and the final results that are formulated through reflection (Löwgren, Larsen and Hobye, 2013). This leads to constructive and holistic design research
knowledge in which theory and practice are framed in parallel (Löwgren, Larsen and Hobye,
2013). Furthermore, programmatic research approaches are on-going, which means that rather
than producing one final outcome, programs produce a design repertoire in the form of specific
interventions and takeaways as a reflection on the program as a whole (Löwgren, Larsen and
Hobye, 2013).

In this thesis I follow these basic outlines of a programmatic research approach by reflecting
upon multiple design experiments that I have carried out, often in collaboration with others,
over the past two years. My aim here is to both provide an extension of existing methods in
technologically mediated human-animal interaction as well as contributing to a larger design
repertoire in a new design field. However, programmatic research is usually considered a long
term process with many intensive phases of design and reflection over a timespan of multiple
years. In this project, even though these experiments could form the beginning of a design
research program, I would not claim that it qualifies as a fully integrated programmatic design
approach, because it generally lacks the long-term iterative approach and possibilities for
deep reflection. Instead, as emerges from the theoretical framework in Chapter 4, I only focus
on a specific part of the design experiments including the dynamic relationships between the
different actors that constitute the interaction. In the next section of this chapter I will describe
how I will approach this within the context of this thesis project.

5.3 METHODOLOGICAL APPROACH

Using the basic outlines of a programmatic research approach and inspired by the work of
Latour and Haraway as argued in Chapter 4, I will reflect upon a total of six prototypes that I
have developed and tested over the last few years. My aim is to visualise and reflect upon the
dynamic relationships between the animal, human, and design artefact that are made and
remade within the course of the interaction.

To build a design repertoire, these six artefacts will first be presented in the form of a design
gallery in Chapter 6. For each artefact I will describe the design concept and experiments
supported with visualisations of the prototypes and testing.

Subsequently, in Chapter 7 I will start to concretely visualise the notion of becoming with
between animals, humans, and artefacts, and explore the relationships between the involved
actors as the interaction unfolds. These dynamic processes will be reflected upon through
annotated videos in which I aim to visually map the interactions that can be observed. For each
prototype, I will reflect upon these annotated videos together with the involved designers with
the aim to better understand the mediating role of the technological artefact that we designed.
For the first four prototypes, the reflection will be focused on the becoming with of the humans
and animals that participate in the interaction with the artefact with the goal to evaluate the
design of the prototypes. The last two prototypes, which have been designed and developed
within the timeframe of this thesis, specifically focus on the reflection on becoming with the
animal as a human designer during the design process. Whereas the first four artefacts are
reflected upon using videos of the prototype testing, the last two design experiments will be
visualised in different iterative stages of the design process in which the designer and animal
explore new ways of interacting with the artefact together.

The conclusions and takeaways of this project will be presented in Chapter 8.
6. Design Gallery

This chapter presents an overview of the six prototypes that are included in this project. For each design artefact, I describe the concept and experiments both in words and images. I also include the names and roles of other designers that have contributed to the three projects that were not carried out individually. The aim is to create a design repertoire of playful interactions between humans and domestic animals that can then be evaluated and reflected upon. The first four prototypes are presented as finished projects that include a specific design artefact. The last two prototypes are developed within the timeframe of this thesis and present an iterative design process including different stages of experiments in which the designed artefact develops over time. In order to contribute knowledge in the form of an open design repertoire, I described the technical details and tutorials for most artefacts on my online Instructables profile so that others can iterate, remake, expand, or improve our work. ([http://www.instructables.com/member/Colombinary/](http://www.instructables.com/member/Colombinary/))

6.1 ARDUINO DOG

*Arduino Dog* is a project that I individually carried out for the Embodied Interaction course as part of the MSc in Interaction Design at Malmö University. Since the assignment was to make a game with Arduino and Processing using physical buttons, I decided to make a simple videogame that could be controlled by a dog. To do this, I made physical buttons with MDF wood, aluminium foil, and sponge, and I used the Arduino Uno (+ the IDE), a breadboard with some wires, and I coded the game in Processing (see figure 11 and 12).

![Figure 11: four physical buttons](image1.png)  
![Figure 12: Arduino and breadboard set-up](image2.png)

The design artefact consist of four physical buttons that control the virtual dog character in the videogame that can go up, down, left, and right. The goal of the videogame is to collect as many dog-bones as possible within one minute. The human has to encourage the dog to voluntarily step on the correct buttons at the right times and use positive reinforcement to complete the game (see figure 13).
The most interesting thing about this assignment was the chance to rapidly prototype and test a simple playful human-animal interaction that is mediated by technology, without the possibility to spend a lot of time on the design. This approach was possible because of the personal understanding and experience I have with my own dogs. I have a general understanding of their abilities, signals, and motivations (such as play or food incentives), which made it possible to carry out this experiment. During the testing of the prototype, I noticed that the artefact itself does not provide any interesting feedback to the dog and she is therefore focused on the body language, voice, and rewards that the human provides. However, observing the signals that the dog communicated, such as a wagging tail, eye-contact, upright ears, I think it was an over-all positive experience for both of us.

6.2 DOGSCOTCH

For the Global Game Jam 2014, together with Alex Camilleri, we made a digitally augmented variant of the folk game hopscotch that can be played together with a dog. In the activity of play, humans can form complex abstractions and embrace structured rules to experience games. We often use our imagination while playing games; dogs mostly perceive the environment the way it is. These two opposing perceptions come together in this game, created in 48 hours inspired by the theme of the game jam: “We don’t see things as they are, we see them as we are”

For this game we used a projector mounted on the ceiling that projects on the floor and we created a prototype of the game using Gamemaker Studio software. In order to play the game you will need one human player, one dog player, a dog toy, some dog treats, and a human assistant with a mouse (see figure 14).

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1 Alex Camilleri (design, programming), Michelle Westerlaken (design, art)
During the game, the players jump from one tile to the next as fast as possible and on each tile a small challenge appears that they have to carry out together before they can jump to the next tile. These challenges include for example balancing a dog treat on your feet, letting the dog fetch a toy, throwing a treat on a specific tile, or avoiding virtual fire-balls that appear on the floor. Each challenge is visually supported on the projection and the human assistant assesses if the challenge has been completed so that the next tile can be opened (see figure 15, 16, 17, and 18).

During the prototype testing, it seemed like both the humans and dogs had fun. They all joined voluntarily and spent active time together exploring mutual understanding through body language and behaviour, encouraged by the technological artefact. We believe this experimental game proposes interesting questions and explores new areas of play between humans and animals.
6.3 STAIRWAY TO COOKIE HEAVEN

As part of our a course called Play and Ludic Interaction for the MSc in Interaction Design at Malmö University, we built a prototype for a game that can be played together by both dogs and humans. Together with Inge van Hoppe and Dariela Escobar, we aimed to explore how two different species can enjoy a playful activity together. The video game is made with GameMaker Studio and is projected on the wall. The player controls the game wireless with a PS3 controller. The physical elements of the game include 8 different MDF shapes and 14 different dog puzzles that we cut out with the lasercutter, assembled, and painted with non-toxic materials. The puzzles attach to the shapes with magnets for extra safety (see figure 19 and 20).

This game is a hybrid between a series of physical objects that contain dog puzzles and a digital videogame that is projected on the wall. Next to simply enjoying time together with a dog, the goal of the game is to build a stairway for the dog towards a dog treat that is attached to the wall and defend this treat from the cookie-monsters in the video game. Each part of the stairway contains a puzzle that the dog needs to solve, before the player can build further (see figure 21, 22, 23, and 24).

2 Dariela Escobar (design, physical prototyping, shape laser cutting, game art), Inge van Hoppe (design, physical prototyping, puzzle laser cutting), Michelle Westerlaken (design, physical prototyping, game programming)
Felino is a tablet game for cats and humans that has been developed together with Alex Camilleri during the past two years\(^3\). The goal of the game is to afford both the cat and human with a relevant role during the interaction. Instead of a game with structured rules and objectives, it aligns more to a digital toy, allowing the human and cat to experiment with the game mechanics. The game represents a top-down aquarium in which fish and other colourful sea creatures swim and can be caught by the cat. Each fish has a specific look and behaviour that allows the cat to experience a degree of unpredictability and variation while playing. By using virtual controls placed at the bottom of the screen, the human player can alter game attributes, such as the size and speed of the fish, and regulate the movements of in-game objects in order to align the game to the specific preferences of the cat. One specific virtual control that the human can use consists of a small joystick that regulates the movement of a crab. With this crab, the human player can collect spheres that are released whenever the cat catches a fish. By collecting these spheres, other small crabs are created behind the main one, generating a trail that the cat can interact with. With this, the interactions of the cat with the game generate resources for the human to collect, which creates a gameplay loop in which all players can participate (see figure 25 and 26).

As human developers, we tried to design a game that adheres to the sensory perceptions and playful behaviour of the cat. This means that rather than including conventional mechanics such as time pressure, high scores, or game-over states, we based our design decisions on our interpretation of available animal research regarding for example the eyesight, colour perception, and playful behaviour, of cats. We also decided to avoid human interface elements that could interfere with the cat’s gameplay, such as introduction menus, textual explanations, or buttons that could unintentionally be operated by the cat. We tested the game with a total of 19 cats (see figure 27) and published the results elsewhere (Westerlaken, 2014; Westerlaken and Camilleri, 2014; Westerlaken and Gualeni, 2014b).

\(^3\) Alex Camilleri (programming, animations, additional design), Michelle Westerlaken (design, art)
In order to explore a dog's reactions to an interactive robotic object, I experimented with a device called Sphero, a ball that is connected with a smartphone through Bluetooth and can be moved around by a human through an interface on a smartphone.

Over a period of five weeks, I tested the device in different prototype iterations and got very mixed reactions from the two dog-testers. First, I experimented with different covers to make it possible for them to grab the ball by putting a soft texture around it. One of the dogs found it interesting and started to play around with the ball for a short time. The other dog seemed to be a bit scared of the device. After this, I explored the addition of food incentives. First I put some peanut butter on the ball, which the dogs seemed to find pretty interesting, but within a very short time they both started to pay more attention to the peanut butter smell on the floor rather than the ball itself. Then I put a small dog treat inside the soft texture, this made the dogs very interested in the device and it was fun for me to play around with the ball, trying to escape from the dogs, as well. I found that it was either too easy or too difficult for the dogs to get the treat out and lose their interest. Then I experimented with a special rubber cover that can be put around the Sphero to make it go faster. The dogs found the new texture interesting and one of them started to play around with it. I also put small dog treats inside the rubber and with this the challenge for both me (roll the ball away from the dogs) and the dogs (trying to get the treat out) remained interesting and playful for about 15 minutes (see figure 28 and 29).

Later, I developed a lo-fi prototype for a dog puzzle containing dog treats that can be mounted on top of the Sphero using Lego bricks. While I was trying to manoeuvre the artefact, the dog tried to solve the puzzle and find the treat. One of the dogs did not want to participate in this experiment, but the other one was very interested and we played with the prototype for about 30 minutes (see figure 30 and 31).
After this, I developed a hi-fi prototype with MDF including four different types of dog-puzzles that can be mounted on top of the Sphero with the use of a laser cutter (see figure 32 and 33)\(^4\).

Figure 32 and 33: hi-fi prototype

### 6.6 EXPERIMENTATION WITH PLAYFUL INTERACTION INCLUDING SOUND AND SMELL

For this experiment, I built a prototype dog toy that could capture both sound and smell. I started with a lo-fi prototype including a soft toy in which I could hide a phone that played pre-recorded sounds that could be recognizable for the dog. Another compartment of the toy contained objects that had a specific recognizable smell. By testing the toy with the dogs I wanted to explore their playful responses and general interest in this type of interface. In order to provide sounds and smells that the dogs could find both interesting and recognizable, I asked a family member to send me smells and sounds that connect to her home environment, a place where my dogs often spent the first few years of their life as well as the summer holidays. She sent me objects such as a towel that remained inside the dog bed of her own dog, some branches from the forest next to the house, a dog toy that my dogs are familiar with, and a t-shirt worn by a family member. The sounds included 20/30 seconds audio files with sounds of the other dog, the local forest, sounds from inside the house, and a talking family member.

Figure 34 and 35: introducing a lo-fi prototype

When I introduced the prototype (see figure 34 and 35), both of the dogs were immediately interested. It was a new item and I introduced it in a playful way, allowing them to sniff it, bite it, and take it anywhere they wanted. I noticed that they were very interested in smelling the toy

\(^4\) These dog puzzles are inspired by the dog puzzle design carried out in the Stairway to Cookie Heaven project (Chapter 6.3) in which I collaborated with Dariela Escobar and Inge van Hoppe. Additional thanks to Dariela Escobar for her help with creating the Illustrator files.
with the different smells that I provided. The sounds, however, gave mixed reactions. When the phone played low-volume sounds, the dogs did not seem to react to it in a very clear way, but when the sounds were louder, one of the dogs tilted her face while looking at the toy multiple times, signalling her trying to identify what is going on, while the other dog immediately left the prototype (either because she found it intimidating or perhaps it was scary). Later on, I took the smelly objects out of the prototype and presented them to the dogs (see figure 36 and 37) and this was a very interesting experience as well. In both cases, the dogs were interested in the smell of the object for a long duration of time. Especially in case of the towel that had been with another dog: my dogs spend about 3 minutes smelling the towel from all sides and continued doing this when I presented the object again the following days.

The main intention of these experiments was to provide the dogs with a sense of control over when the sounds would be activated. Therefore I would only play the sound when the dog was interacting with the toy. In order to extend this concept, I developed a hi-fi prototype including a stuffed animal with an Arduino, an Audio Wave Shield, a speaker, and an RFID reader/antenna. Additionally I added RFID tags to the collars of my dogs. With this prototype, the sounds were automatically activated whenever the dogs would come close to the toy (with a 7cm reading range of the RFID antenna). For each dog I recorded and selected five different sounds based on my personal understanding of what they would prefer (one of the dogs seems to dislike loud noises so she could only activate low-volume sounds, whereas the other dog is more playful so she could start louder and more active sound files). The dogs were also interested in this prototype and we played together for about 30 minutes. The dogs started different sound files during the testing and extensively smelled the part of the toy that contained the added smells. After the play session I additionally used the prototype as a starting point for exchanging affection and to experiment with sound files that are specifically created as ‘calming music for dogs’ (Through a Dog’s Ear - Music Therapy for the Prevention and Treatment of Canine Anxiety, 2015). One of the dogs seemed to appreciate these sounds and she approached me and the prototype. When I started to pet her she sat down next to me and, after extensively sniffing the prototype for a minute, eventually fell asleep on top of the prototype. (see figures 38 and 39).
As outlined in the previous chapters of this thesis, in this section I will reflect upon the six prototypes by visualising the interaction networks between the animal, human, and artefact with the use of annotated videos. For each of the prototypes described in the previous chapter I produced a 1-2 minute video of the interaction. Subsequently, I visualised the dynamic interactions through animations that play alongside the interaction videos. The annotated videos of the first four prototypes (Arduino Dog, Dogscotch, Stairway to Cookie Heaven, and Felino) focuses on the interaction network of a single play session with the artefact, one animal, and one human. The reflection on these annotated videos is therefore focused on the interaction network and *becoming with* between the animal and human during the interaction itself. For the last two prototypes, the annotated videos show the interaction network between human, animal, and prototype at different points during the design process. In this case, the reflection is focused on *becoming with* the animal as a designer during the design process in which the animal is invited as a participant.

To make the animations of the interactions I specifically focused on what happens between the animal, human, and artefact. I animated their relationships with each other (the circles overlap with each other or move away from each other), I looked at the actors that initiate the interaction (the circles that start moving towards others), and animated the actors I perceived as more or less dominant during the interaction (the height of the circles compare to each other). Even though these networks could have been visualised in many different ways, the main objective of these animations is to provide a tool for reflection and discussion among the designers in order to better understand our designs and come up with valuable design iterations. I therefore showed the annotated videos to all the designers that were involved in each prototype and asked them for their thoughts, feedback, and input. This facilitated very interesting discussions and new ways of reflecting upon the interactions we designed. In this chapter I provide a summary of these discussions.

**Arduino Dog**

Youtube.com link (with sound) https://youtu.be/manlyHM4V4E

Archive.org link (without sound) https://archive.org/details/annotated_videos

While reflecting on this annotated video, the division between the physical and a digital part of the artefact becomes particularly clear in the difference between the animal’s and the human’s interaction. While the animal is only interacting with the human and the physical part of the artefact, the human needs to divide her attention between all the elements. Taking a closer look at the more abstract animation, it can often be observed that whenever the human pays more attention to the digital part of the artefact (mainly through eye contact), the animal and human move away from each other. In other words, even though the artefact offers a way for the human and animal to interact with each other in a playful way, their *becoming with* is mainly enforced by the physical part of the artefact. However, the interaction is mainly guided by the digital element, which encourages the human to guide the animal on the physical part of the artefact, creating a loop in which all four elements (digital artefact → human → animal → physical artefact) have a fixed and repeated role. It could therefore be interesting to experiment with...
iterations that bring the physical and digital part of the artefact closer together (for example with a projection or screen directly under the physical buttons). Next to this, it could be interesting to explore ways in which this fixed gameplay loop can be changed by providing the animal with feedback and encouragements from the artefact itself (for example through sound) instead of allowing only the human to encourage and reward the animal.

**Dogscotch**

Youtube.com link (with sound) [http://youtu.be/5BpZcjk4WKg](http://youtu.be/5BpZcjk4WKg)

Archive.org link (without sound) [https://archive.org/details/annotated_videos](https://archive.org/details/annotated_videos)

This annotated video shows how the digital artefact is providing an impulse for the human to interact with the animal approximately every 10 seconds. Even though the animal is never interacting with the digital artefact itself in a direct way, the artefact invites the human to carry out the challenge together with the animal. Since these challenges are communicated through short sentences and projected on the ground (close to the animal), the attention of the human only deviates from the animal for a short instant each time a new challenge is presented. The video annotation also shows how the animal is dependent on the human for their input and feedback (in the form of language, bodily signals, and movement). Additionally the human is dependent on the artefact’s input and feedback (in the form of written text and visual animations). In general I think that this interaction provides multiple clear moment in which the human and animal are becoming with when they are successfully completing the challenges, even though these moments are invited through the mediation of the artefact and guided by the human. In possible design iterations it could therefore be further explored how the animal can gain more control over the interaction. For example by providing challenges that are initiated or guided by the animal, such as challenges in which the human has to follow, mimic, or interpret the animal’s behaviour or playful signals. In this case, a challenge might include “mimic your dog for five seconds”, or “let your dog choose between two toys to play with”. This could create a bigger and more equal role for the animal during the interaction.

**Stairway to Cookie Heaven**

Youtube.com link (with sound) [http://youtu.be/SUvfc5BQkN8](http://youtu.be/SUvfc5BQkN8)

Archive.org link (without sound) [https://archive.org/details/annotated_videos](https://archive.org/details/annotated_videos)

The interaction with this prototype consists of a digital and a physical part. The annotated video shows how the human is constantly going back and forth between the digital and physical artefact, which are separated from each other. The animal, on the other hand, is mostly going back and forth between interacting with the physical artefact and the human. This creates an unsymmetrical interruption in the way the human and animal can interact with each other. Rather than facilitating interaction between the human and animal, the artefact (especially the digital part) requires the human to divide her attention between all the elements. This causes moments in which the animal seeks contact with the human, but the human does not directly respond. Possible design iterations could therefore focus on staging the interactions with the artefact and each other in more symmetrical ways. This means that the interaction of the human with the digital artefact can for example be timed together with the interaction of the animal with the physical artefact. Moreover, we can then design interactions in which the human and
animal connect with each other during the moments in between. This way, the human and animal can *become with* when they are simultaneously looking for interaction with each other.

**Felino**

Youtube.com link (with sound) [https://youtu.be/FNlLLskpIpw](https://youtu.be/FNlLLskpIpw)

Archive.org link (without sound) [https://archive.org/details/annotated_videos](https://archive.org/details/annotated_videos)

This annotated video visualises how the interactions of the human and the animal with the artefact are independent from each other as well as encouraged by each other. The annotated videos of other prototypes often show how the animal’s interactions are dependent on the human. In *Felino* both the human and the cat can interact independently with the artefact. Moreover, the visualisations show that when the human starts to interact with the artefact, the animal often follows. And the other way around, when the animal starts to interact with the artefact, the human is also encouraged to start interacting with it. It can also be observed how the human sometimes takes more distance from the animal and the artefact when they are interacting with each other. In the video it can be noted that in these cases the human is simply observing the cat’s play with the tablet. At some point during the interaction the *becoming with* between human and animal becomes particularly clear when the animal initiates contact with the human and she responds by petting the cat. This video shows how their *becoming with* is repeatedly mediated by the artefact but not depending on one specific actor. Possible design iterations could explore way in which the interaction with the artefact can become more engaging or challenging for the human so that, instead of merely observing the interaction, the human feels encouraged to take part in it more often.

**Experimentation with a playful robotic object**

Youtube.com link (with sound) [http://youtu.be/OXbPfOjVE1g](http://youtu.be/OXbPfOjVE1g)

Archive.org link (without sound) [https://archive.org/details/annotated_videos](https://archive.org/details/annotated_videos)

This design process is characterised by a chosen limitation on the core part of the artefact, which makes it both interesting and challenging to come up with new iterations and experiments that change the way in which the interaction is shaped. This also becomes clear in the video that shows how the main mechanic of the artefact remains very similar throughout the entire design process: the human provides an input to the digital artefact, which sends a signal to the physical artefact and encourages the animal to interact with it. The annotation demonstrates this as well, since the interaction between the animal, human, and artefact is mostly structured in a similar way. The separation between the digital and physical artefact also seems to encourage the human and animal to move away from each other during the interaction, rather than get closer together. This gave me more ideas about the design context in which this type of interaction could become more valuable, such as for enabling interaction between animal and human from distance (for example when the dog is home alone), or through a fence (for example in the context of a zoo or animal shelter). In this case, rather than separating the existing connection between human and animal, the prototype could create a remote sense of *becoming with* that was not there before the mediation.

On the other hand, the most interesting moments in this documentation of the design process occur when the human and the animal seek direct contact with each other. For example when
the human is encouraging the dog to interact with the physical artefact by sending out indexical body signals (such as pointing to the physical artefact), or when the dog looks for support from the human by jumping on her lap or making eye contact. These types of interactions, and the way the human and animal respond to each other in these instances, show a way in which the animal and designer are becoming with during the design process itself. By looking at the annotations, it occurred to me that the human and animal are the closest to each other during the moments before or after the interaction with the artefact.

New experiments with this prototype can further explore these two aspects. First, the designer can open up for new design contexts in which the prototype can be tested. And second, the becoming with before or after the interaction with the prototype can be further explored by making these moments a more deliberate part of the experiment itself.

**Experimentation with playful interaction including sound and smell**

Youtube.com link (with sound) [https://youtu.be/H4jdC1-wcuA](https://youtu.be/H4jdC1-wcuA)

Archive.org link (without sound) [https://archive.org/details/annotated_videos](https://archive.org/details/annotated_videos)

For this design process I wanted to experiment with a toy that could facilitate becoming with between human and animal using an interface focused on sound and smell. This video shows different ways in which the prototype can be used and this also shapes the way in which the human, animal, and artefact interact with each other. For example, when the human and animal are playing with the toy together by grabbing, throwing, and pulling the artefact, they are connected through play and become with by directly responding to each other’s signals and behaviour. In other cases, the animal is exploring the object’s sounds and smells and the human is observing the interaction from short distance. In the last part of the video, the human and animal are closely connected through the exchange of affection and the artefact serves more as a mediation supporting this interaction in the background.

In all these examples it becomes clear how the designer and animal can become with through exploring the artefact and its affordances together on their own terms and directly reacting to each other’s signals and behaviour. I found this process very valuable in exploring the different use scenarios and possibilities of the prototype together with the animal. During this design process it became clear that this prototype can facilitate interaction in different ways that I did not intent upfront. For example, when I started to present the different smells to the animal and noticed how they spent quite some time curiously sniffing the artefacts, I iterated upon this experiment in order to enable the artefact to facilitate this more calm interaction by integrating relaxation music as a starting point for the human and animal to exchange affection. The annotated video demonstrates how the human and animal are becoming with in very different ways throughout this iterative process.

This design process was characterised by very personal ways in which the prototype could facilitate becoming with between me and my own dogs. However I believe that this prototype is particularly suitable for further design iterations by allowing other people to use this artefact to do similar experiments with their dogs. In this case I would ask people to collect different smells that their own dog might find interesting and record their own sounds that can be uploaded to the SD card that is integrated in the hardware of the artefact. In this way I could observe others to becoming with and explore new use scenarios and design contexts together.
8. Conclusions and Takeaways

In this thesis I first outlined a theoretical framework in which I advocated for the adoption of a more informed form of anthropomorphism that we can use for the design of interactions in which animals are invited as legitimate participants in the design process. Drawing from the work of Latour and Haraway, I suggested to further explore the notion of becoming with through playful interaction design in order to strike upon and respond to respectful relationships with animals in actual situated contexts. Here, the term 'playful' refers to Sicart's understanding of playful designs that is not necessarily limited to toys or games but also includes interventions that open up for respectful and meaningful conversations between human and animal in other ways, such as through affection, reward, or pleasurable cognitive challenges.

Subsequently I proposed to reflect upon the relationships between the involved actors in concrete playful design contexts through visualisations of the interaction networks. Since these networks are a dynamic process that is constantly changing and evolving, I suggested the use of annotated videos to animate the interactions between animal, human, and technological artefact. These reflections can then be used as a tool for designers to better understand the mediating role of technological artefacts and the ways in which the interaction is composed, how it develops, and how it ends. Using the basic outlines of a programmatic research approach, I reflected upon a total of six prototypes, four of which were developed over the last two years and two that are developed during the timeframe of this thesis. Through this approach I aimed to generate knowledge that offers new methods and insights to bring us one step closer to answering the so called 'big question' that I stated in this thesis: how can we design technologically mediated interactions, both for and with animals, with the goal to better understand them and enrich or improve their lives?

Through visualising these dynamic interaction networks, the relationships between the animal, human, and artefact became more abstract and resulted in a better understanding of the role of the technological artefact. During the initial design process, we, as designers, were often deeply invested in developing working prototypes that realised our ideas, which made it difficult to articulate the ways in which the interactions are shaped on a more abstract level. The annotated videos allowed us to discuss and reflect upon the relationships between different actors and compare this with our original design intentions, which opened up for new ways of discussing potential iterations. Each prototype had major differences in the way the interaction network was visualised and the annotated videos showed to be a valuable tool for the designer to discuss new design iterations that could be explored further. Four of the annotated videos focus on the interaction networks of the actors that are involved to explore the notion of becoming with during the interaction itself. Rather than analysing the interactions with the artefact of each actor separately and taking the risk of drawing superficial anthropomorphic conclusions based on our human observations of the animal, this method allows designers to focus on what happens between the actors and reflect upon how the artefact mediates the dynamic relationships between human and animal. The remaining two annotated videos have a focus on the becoming with that takes place between the animal and the designer during different stages of the iterative design process. These reflections demonstrated how this method can invite the animal as a valuable and legitimate participant during the design process without the need to assess animal behaviour in rigorous ways. Instead, the animal and designer could explore the
different prototype iterations freely on their own terms and together, through becoming with, they came up with new iterations, contexts, and use scenarios. The knowledge contributions and takeaways of this thesis project therefore consist of:

- a new theoretical framework, inspired by the work of Latour, Haraway, and Sicart, that outlines the importance of adopting more informed forms of anthropomorphism in which the animal is invited as a legitimate stakeholder in the design process;
- a new method that can be used for the visualisation of the dynamic interaction networks that are constantly being made and remade as the interaction between animal, human, and artefact unfolds, with the goal to offer designers a tool to better understand the relationships between the animal and human as well as the mediating role of the technological artefact;
- a design repertoire with six different prototypes that are presented in the form of a design gallery including visuals and a reference to more in-depth descriptions and tutorials regarding the making of these projects;
- The annotated videos as concrete takeaways that provide a deeper insight into the experimentation, testing, and reflections of the six different prototypes;

During this project I have attempted to introduce a new way in which we can evaluate and reflect upon the design of technologically mediated interactions including both humans and animals. However, this project addresses only a small part in answering a much larger research question and is limited to the few humans and animals that could be included in the design and evaluation process. This resulted in a generally personal project, in which my designs, ideas, and visualisations, and my dogs’ characters, size, and willingness to contribute, largely shaped the outcomes of my work. Next to this, because of the time intensive process of making the animations, the annotated videos could only show a small portion (around one to two minutes) of the interaction that took place during the testing. In reality, different testing sessions with the same artefact naturally showed a difference in the way the relationships between animal, human, and artefact were shaped. Nevertheless, by annotating a video of a complete play session for six different prototypes, it was possible to observe how the interaction networks differ for each artefact and illustrate diverse ways in which the animal and human can become with through technical mediation. With this, I think this thesis can contribute valuable knowledge in the academic field of technologically mediated human-animal interactions as well as the practical field of interaction design for humans and animals. Further research could extend and critique the framework and method that I introduced in this thesis by exploring and validating this visualisation method in different areas of design research. It would be specifically interesting to evaluate multiple play sessions of different participants with a single artefact through these annotated videos in order to discover distinctive patterns or insights that can lead to new design iterations. Next to this, I hope other designers will find the design repertoire useful and valuable in their own iterations and in the critical assessment of my work. Finally, in this work I have used the basic outlines of a programmatic research approach through carrying out multiple design experiments and specifically reflecting on how dynamic interaction networks are shaped for each artefact. Through continuing my work in this area, I aim to extend this programmatic approach with the design and development of interventions in different contexts, with different animals, and by advancing the types of theory and reflections that I used in this project in order to contribute new knowledge on both abstract (through theory) and concrete (through design) levels.
References


