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Theorizing animal–computer interaction as machinations

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ABSTRACT

The increased involvement of animals in digital technology and user-computer research opens up for new possibilities and forms of interaction. It also suggests that the emerging field of Animal–Computer Interaction (ACI) needs to reconsider what should be counted as interaction. The most common already established forms of interaction are direct and dyadic, and limited to domesticated animals such as working dogs and pets. Drawing on an ethnography of the use of mobile proximity sensor cameras in ordinary wild boar hunting we emphasize a more complex, diffuse, and not directly observable form of interaction, which involves wild animals in a technological and naturalistic setting. Investigating human and boar activities related to the use of these cameras in the light of Actor-Network Theory (ANT) and Goffman's notion of strategic interaction reveals a gamelike interaction that is prolonged, networked and heterogeneous, in which members of each species is opposed the other in a mutual assessment acted out through a set of strategies and counter-strategies. We stress the role of theory for the field of ACI and how conceptualizations of interaction can be used to excite the imagination and be generative for design. Seeing interaction as strategies and acknowledging the existence of complex interdependencies could potentially inspire the design of more indirect and non-dyadic interactions where a priori simplifications of design challenges as either human or animal can be avoided.

1. Introduction

Theory, as a way to account for users and their interactions with computers, has a long tradition in Human-Computer Interaction (HCI) research (Rogers, 2012). Theoretical foundations serve to supplement our interactional understanding and inform design in various ways. To emphasize their different roles and impacts in HCI, theories can be categorized as descriptive, explanatory, predictive, prescriptive, or generative (Bederson and Schneiderman, 2003). Hence, theorizing can be a way of seeing things from new perspectives and discovering original and interesting features that can inspire design and drive it forward, but it is also indispensable when old theories become outdated due to improvements and novel adaptations of digital technology. Such enhancements lead to new situations and forms of interactions that require new or revised theoretical advancements in order to make sense and to be further developed.

As digital technology continues to develop, enabling the computer to “reach out” (Grudin, 1990), it not only becomes involved in every aspect of the human world, but also begins to encompass animals in different ways. This has created such a “new situation,” demanding that we understand our new animal users and find ways to account for the new set of interactions it makes possible. Animal–Computer Interaction (ACI) is a young and emerging field, with only a small number of explicitly formulated approaches to interaction (i.e. Juhlin and Weilenmann, 2011; Mancini et al., 2012; Aspling and Juhlin, 2015). To a large extent HCI theory is built upon implemented perspectives from other disciplines within the humanities and the social and behavioral sciences. Those theories are most commonly designed with humans and human abilities in mind, and their use is limited to the human realm. Hence, the emergence of animals in the study of user-computer interaction challenges previous accounts of interaction, and evokes new design challenges. In classical HCI, the starting point has been theories deriving from psychology that emphasize cognitive processes in the mind of the human user, but when animals are included such a theoretical starting point becomes more problematic (Juhlin and Weilenmann, 2011). The second wave of HCI research, or “the social turn,” is also challenged by the appearance of animals. Even if we to some extent can communicate with other animals, we do not share a language with them and have difficulty entering their minds and understanding their worldviews. Designing for animals and for human–animal interaction implies a need to understand our new animal users and find ways to account for the growing set of new interactions.

So far, ACI has mostly focused on studying domesticated animals in a restricted set of situations. On the one hand there is research and design focusing on working dogs, where the design

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agenda is task-driven, supporting the animals in their work of helping humans with tasks such as detecting cancer (Mancini et al., 2015), alerting diabetics to low blood sugar (Robinson et al., 2014), assisting blind people (Melin et al., 2015), and hunting (Juhlin and Weilenmann, 2011). On the other hand, there is research and design concentrating on developing interspecies games (e.g. Tan et al., 2007; Cheok, 2010;), especially between humans and pet cats (e.g. Pons et al., 2014). However, rather like how computing has become ubiquitous, nonhuman animals are omnipresent in the lives of humans, and we interact with them in many different ways (see for example DeMello, 2012). This makes the potential design space for ACI wider than just domesticated animals, as we have previously have pointed out (Aspling and Juhlin, 2015) when linking ACI with urban studies and underlining the possibilities that digital technology offers for re-configuring animals' city life. Moreover, and perhaps even more importantly, we showed how the ACI design agenda could incorporate design grounded more closely in the animals' own interests outside the lab. In this case, we did so by looking at what gets their attention in an ordinary, natural, everyday setting, rather than focusing on their interests in a pre-constructed design scenario such as solving specific tasks or taking part in interspecies games. Moreover, the most common interactional forms within ACI are direct, where the interconnected actions are performed synchronously with a clear connection between cause and effect. Furthermore, by focusing on two individual entities, such as an animal and a computer system, ACI is most typically structured around dyadic interaction.

We suggest that in order to "excite the imagination" (McGrath, 2009, p. 2533) an important task for ACI is to ground future design in theories of interaction, as a complement to creative attempts to use new technology. Previous ACI researchers have either diminished the relevance of the area per se (Mankoff et al., 2005), or have justified their research from an animal rights position and expect their work to be misunderstood and ridiculed (Lee et al., 2006). More recent research includes using ethnomethodology to understand manifest computer-mediated interactions between people and animals (Juhlin and Weilenmann, 2011), or experimental and participatory design approaches that study effects of various design interventions (e.g., Mancini et al., 2015; Robinson et al., 2014). Although this emerging research does account for interaction, both approaches require paying close attention to embodied details in empirically available direct interaction. Hence, they seem appropriate when accounting for interactions that are direct and dyadic. Furthermore, both of them can involve animals in design, either by presenting a design prototype for the animals to react to in a lab setting, hence making them part of the design work (e.g. Mancini et al., 2015; Robinson et al., 2014), or by carefully examining the animals' doings and possible intentions in ordinary and naturally occurring situations in their daily lives as a basis for design (Aspling and Juhlin, 2015). However, these approaches seem inappropriate for the empirical case and use of technology presented in this article. It points towards an alternate and underexplored type of interaction that is more diffuse and less directly observable, and that therefore risks remaining unseen.

We present an ethnographic study of the use of mobile proximity sensor cameras within ordinary wild boar hunting, with the aim of broadening our interactional understanding and expanding the design opportunities for ACI. Our empirical case emphasizes the use of new digital technology in a naturalistic setting "in the wild," and involving both humans and, in this case, wild animals in the form of boars. It focuses on how these two species interact in this new and rather high-tech landscape. The practice of hunting, one of the oldest forms of human-animal interaction is becoming increasingly dependent on digital technology such as GPS-trackers (Juhlin and Weilenmann, 2013) and mobile proximity sensor cameras. The latter add a visual dimension to the hunt and promote a form of interaction that is not as direct as the pre-existing ACI interaction forms. Instead it is diffuse, scattered over time and space, lacks the co-presence of the actors, and is consequently not directly visible to an external observer such as a researcher. Further, it illustrates interaction that is indirect, in terms of being prolonged in time and space, and non-dyadic in terms of encompassing a complex and heterogeneous setting including the environment and several other nonhuman and human actors. Faced by such relations, we are interested in finding ways to account for technically mediated interactions with wild animals, and to conceptualize such interactions.

Central aspects of Actor-Network Theory (ANT) are potentially relevant. Its way of including nonhumans in social analysis has been influential in other disciplines influenced by posthumanist thought, such as animal geography (see for example Buller, 2015). It is also interested in understanding the mechanisms of power and in including artifacts in such analyses (Latour, 1988a, 1991). ANT is used to explore what this means in terms of interaction and to contribute theoretical and methodological insights to the growing field of ACI. It reveals concrete programs of action that include the role of artifacts. It does so by understanding interaction as a struggle for power between different diffuse actor-networks consisting of intermingled humans and non-humans (e.g. Latour, 1988a, 1991). Additionally, ANT illustrates the role of technology in making them associated with each other in networks.

In our case of hunting and proximity sensor cameras, ANT exposes interactions between hunter and boar that are game-like insofar as the participants are engaged in a conflicting set of programs of action and strategies where technology plays a crucial role. With the help of ANT and the notion of program and anti-program (Latour, 1991) and Latour's (1988a) updated analysis of Machiavelli's (1513/1966) understanding of the mechanisms and organization of power, we show how interaction can be understood as comprising "strategies." Not unlike Goffman's (1971) use of the notion of strategic interaction to account for "the calculative, game-like aspects of mutual dealings" (Goffman, 1971), this perspective emphasizes that individuals rationally calculate every action, move, and circumstance. Rather than worrying about how they or others are perceived, the participants in the game-like interaction described in this paper are involved in a game of life and death. This requires us to consider a wider arrangement of interactions, consisting of a combination of different interconnected moves and scenarios. For example the hunters engage in procedural and strategic thinking to successfully stage animal-computer interaction by luring the boars into the range of the proximity sensor that triggers the camera, and the boars engage in strategic thinking in order to eat the food provided by the hunters while avoiding being killed.

This paper is structured as follows. In the next section we review previous conceptualizations of interaction within ACI. After that we present relevant aspects of ANT and Goffman's notion of strategic interaction. We then explain the method and setting of the study as well as the technology used by the hunters. This is followed by the findings and analysis where the boars' and hunters' activities and strategies in this new landscape are presented in two separate sections. At the end, we discuss the findings more explicitly in the light of strategic interaction and ANT, and how these theoretical foundations can be generative for design. We also highlight the role of theory in stimulating the imagination.

2. Theories for Animal–Computer Interaction (ACI)

Although the amount of research in the field of Animal–Computer Interaction (ACI) is limited, it already exhibits some of the

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theoretical conceptualizations of interaction that have influenced HCI in general. The study presented in this paper, which aims at developing interactional perspectives for ACI, is influenced by these interactional accounts. In particular, we examine how these approaches has been appropriated to account for interactions within ACI. Before introducing Actor-Network Theory (ANT) and Goffman's interactional framework of "strategic interaction," which are proposed as the basis for an alternative approach to interaction, we will categorize and review the pre-existing interaction approaches that can be discerned within ACI.

2.1. Behaviorism and psychology

The system suggested by Lee et al. (2006), which enables a poultry owner to caress a bird remotely, is supported by the psychological theory of stimulus and response. The human owner strokes a hen-like object equipped with touch sensors. The bird wears a jacket, which outputs the owner's strokes. Conversely, the jacket senses movements of the bird's legs, transforming the signals into low-level electrical currents in the user's shoes. Its usefulness is demonstrated in an experiment where hens' behaviors are oriented towards acquiring stimuli instead of avoiding them. We argue that this research is influenced by behaviorism, though not explicitly. Behaviorism has been a strong tradition within animal research (Goode, 2006), and sees interaction as a set of stimuli and responses. It also discards any more ambitious ways of relating to animals. The selection of such an approach by Lee et al. (2006) is reasonable since HCI has traditionally had a strong connection to psychology. In the early 1980s HCI was primarily focused on interactions where people were working in front of single computers, usually in an office setting. This "classical" (Rogers, 2012) period of HCI relied heavily on the psychology of the human mind and experimentation. The goal was to design usable systems and devices by developing design principles, methods and analytical tools. Special attention was given to users' capabilities and limitations (e.g., memory, attention, perception, learning), and the cognitive processes of users performing computer-based tasks.

2.2. Ethnomethodology and symbolic interactionism

To overcome the simplification of the behaviorist tradition, other researchers within HCI have recently proposed using ethnomethodology and symbolic interactionism to account for the ubiquitous ways in which humans engage with animals. Following Goode (2006), Juhlin and Weilenmann (2011) argue that ethnomethodology is particularly suitable for studying interactions between people and animals, especially interactions with dogs. Although humans and canines have very different bodies and bodily personalities (Goode, 2006, p. 12), ethnomethodology focuses on manifest observable actions rather than inner mental states (Juhlin and Weilenmann, 2011). The approach has been applied to mediated interaction between humans and hunting dogs equipped with GPS-trackers (Juhlin and Weilenmann, 2011) and to more direct and playful interaction between humans and pet dogs (Goode, 2006). More recently, two studies of the use of dogs in cancer and diabetes treatment (i.e. Mancini et al., 2015; Robinson et al., 2014) have taken an interest in the details of direct interaction between animals and technology. Like the ethnomethodological studies, they argue for an "interspecies semiotic framework based on indexicality" (Mancini, et al. 2012). The notion of indexicality, which is also central to ethnomethodology, refers to viewing meaning making as a feature of the concrete situation, and not as part of a mental symbolic language.

These analytic frameworks are influenced by a turn toward the social and contextual that occurred in HCI in the late 1980s and early 1990s. Sociologists and anthropologists were drawn into the HCI discipline, and the individualistic and psychological approach went from solely focusing on internal processes and what happens "inside the head" to also embracing external resources and the context of technology use (Rogers, 2012). As the environment, surrounding artifacts and social context of people interacting with technology became relevant, ethnography developed as a successful method.

2.3. Human and non-human values

HCI research on animals is also motivated from an animal rights position, and proponents of this view pre-conceive their work as bound to be misunderstood and ridiculed. For example, the political concern in the research on "poultry internet" (Lee et al., 2006) is motivated by criticism of the mistreatment of chicken as objects of consumption. Lee et al. argue that "poultry should have the same status as other pets such as cats and dogs because of their similar level of cognition and feelings" (2006, p. 302). Such considerations also inform other studies in their "participatory approach" where animals are invited to take part in doing design (Mancini et al., 2015; Robinson et al., 2014).

This agrees with a direction that emerged within HCI in the mid to late 2000s (Rogers, 2012). A new set of concepts, tools and methods began to appear, with an agenda driven by human values rather than human needs (Rogers, 2012, pp. 65–66). Rogers argues that "different human values came to the forefront, extending and superseding previously mainstream HCI goals to improve efficiency and productivity" (Rogers, 2012, p. 65). This kind of socially aware, engaged and responsible HCI research has led to exploration of topics such as feminism, multiculturalism, sustainability, and poverty. With the emerging strand of ACI research, the welfare of non-human species has been added to this list of concerns. Despite their many positive aspects, politically motivated approaches to ACI have the problem that their standpoint on the issue of interaction becomes subordinated to an ethical or normative imperative. The challenge of articulating the interaction is then handled as internal practicalities in lab work, and therefore neglected as a topic.

In sum, we have suggested that in order to "excite the imagination" (McGrath, 2009, p. 2533) for ACI as a complement to creative attempts to use new technology, it is important to ground future design in theories of interaction. Political and participatory design approaches in ACI direct attention to the area, but this is not necessarily followed by any articulation of how they understand interaction in more compound settings and scenarios. The recent studies drawing on ethnomethodology and symbolic interactionism offer a more enlightening point of departure. However, they are concerned with direct and dyadic interactions and also involve domesticated and sometimes trained animals. Neither of these two previous interaction approaches seems sufficient for understanding more compound and complex forms of interaction, such as that emerging from the use of mobile proximity sensor cameras in hunting.

3. Perspectives on non-dyadic and indirect interaction

In this paper we suggest that a combination of central aspects of Actor-Network Theory (ANT) and Goffman's (1971) notion of strategic interaction is more relevant and appropriate for studying complex and spatially distributed forms of interaction involving animals, new digital technology and humans. These theoretical approaches offer perspectives on interaction that go beyond the focus on dyadic and direct interactions and offer a theoretical account of interaction that is descriptive, conceptual and generative for design.

3.1. Actor-Network Theory (ANT)

ANT was developed in the early 1980s within the field of Science and Technology Studies (STS) with Bruno Latour, John Law and Michael Callon as its principal initiators. Rather than being considered a theory in the traditional sense, ANT is better understood as an approach or analytical sensibility with theoretical and methodological implications. As such, it initially redefined the social by decentralizing humans as the basic unit of social analysis. It propose a conceptual framework where both human and non-human actors are linked together in heterogeneous networks. The rejection of the social as a purely human project is described as generalized or ontological symmetry and strives to eliminate all presupposed oppositions, such as technological/social, human/nonhuman or nature/culture, by combining them in the analysis with the same kind of vocabulary and explanatory framework. For example, both humans and nonhumans are considered as potential actors or actants. Actants are defined as "entities that do things" (1988b, p. 103) and their doings affect other actants and the actor-network as a whole. Hence, agency is distributed in these heterogeneous networks and could be applied to all involved entities. In other words, both humans and nonhumans possess agency from an ANT point of view.

Latour has repeatedly criticized sociologists for not including non-humans in their social analyses, for example in studies of the mechanisms of power and social cohesion. He argues that we can trace every stable social relation we find to relations depending on non-humans (Latour, 1991). Nonhumans are intertwined in our social world to such an extent that we sometimes are unaware of the tasks we have delegated to them, for example the job performed by the hinge of a door (Latour, 1988b). The conception of actor-networks stresses that actors/actants and the networks co-constitute each other simultaneously. If one them changes it affects the other. Hence, ANT is interested not in the structure of the network, but in networking as an ongoing relational activity or process of which the involved actants are the effect. Actor-Network Theory (ANT) is also about power, or rather about revealing the mechanisms and arrangements of power. It sees the creation of networks as a struggle for power between programs and anti-programs (Latour, 1991). A focus on power is also evident in Latour's (Latour, 1988a) attempt to modernize Machiavelli's classic analysis of power in *The Prince* (Machiavelli, 1513/1966), by describing machines and machinations together.

The influence of ANT on HCI is limited and dispersed. Most attention has concerned its heterogeneous notions of agency (Suchman, 2007), materiality (Fuchsberger et al., 2013; Tholander et al., 2012), and interfaces (Dörk et al., 2014), and its usefulness in understanding how to engage in design (Brown and Juhlin, 2015). It has also been used in the field of Computer-Supported Cooperative Work (CSCW), for example in relation to Common Information Spaces (CIS) and the ANT-notion of "immutable mobiles" (e.g. Bannon and Bødker, 1997; Rolland et al., 2006). ANT has also been influential when it comes to unpacking relations with non-human animals. The choice of research sites that "foster multi-species encounters" (Ogden, et al., 2013; Kirksey and Helmreich, 2010) is essential in multispecies ethnography, and ANT has been useful in their mapping. It has also been employed within animal geography (e.g. Buller, 2015; Philo and Wilbert, 2000), a subfield of human geography. Moreover, its way of recognizing agency in non-humans, such as animals (e.g. Callon, 1986; Law and Mol, 2008), has also been influential. Callon's (1986) classic text was an early attempt to apply the principle of generalized symmetry to networks including multiple species. In his analysis, he discussed scallops and fishermen with the same terminology. Ashmore's (Ashmore, 1993) application of a generalized symmetry principle to an actor-network consisting of a cat, a human and a cat-flap is another early contribution. Although these studies display some of the possible ways to include nonhuman animals in an actor-network, they fail to display the actions and machinations *per se*. Callon's analysis lacks a connection to ongoing practices, making it more of an academic exercise. We are looking for a tighter empirical connection between the theoretical notions of ANT and the ongoing practical interaction between hunters, technology and boars.

Further, even if relations between humans and animals are based on actions such as stroking, eye contact, and verbal and gestural commands, they often include artifacts, e.g. leashes, robotic milking systems, fences, fishing rods, bridles, and food bowls. ANT attempts to incorporate humans, non-human animals and technology into the analysis in a symmetrical fashion (Latour, 1996). As human–animal interactions increasingly are entangled in settings dependent on objects and technology, ANT is relevant in accounting for human-animal interactions that go beyond dyadic relationships. This applies especially when it leads to effects of power relations. The direct relation between hunter and prey is something that is far from durable; it is more of a fleeting anti-interaction, where one part plays the catcher and the other does its best not to be caught. Capturing wild animals can be a difficult task, but different kinds of artifacts or technology can stabilize and intensify this relation and make it more durable. With the words of Latour: "in order to understand domination we have to turn away from an exclusive concern with social relations and weave them into a fabric that includes non-human actants, actants that offer the possibility of holding society together as a durable whole" (Latour, 1991, p. 103).

3.2. Goffman's notion of strategic interaction

In his essay on strategic interaction (1971), sociologist Erving Goffman expands the scope of social interaction to "include aspects of hostile, competitive, and adversarial encounters in general" (Burns, 1992) and not only face-to-face interaction. The perspective of strategic interaction involves looking beyond the concrete situation and seeing it as part of a chain of actions and situations, where the moves of each actor influence those of the others in a gamelike interaction. It emphasizes indirect aspects of interaction and involves "participants who are not present to each other, and sequences of moves which are not closely bound by time, whereas, generically, face-to-face gatherings entail mutual presence and brief continuities of time" (Goffman, 1971, p. 140). It accounts for motifs and for how actors understand each other's possible moves and the reactions they may entail.

The conceptualization of strategic interaction focuses only on human strategies; even a lion is part of the discussion about the difference between being *exposed* to danger and being *opposed* by a dangerous opponent. Despite his anthropocentric analysis, Goffman notes that humans and animals can be defined as parties with diametrically opposed intentional interests. A lion can be "expected to track Harry, to pursue him … there is a hint of possibility that the lion could, at least'in effect', read Harry's intentions as well as his presence … Harry, in short, is faced not merely by an inimical force but by an opponent" (Goffman, 1971, p. 93). This example, which implies that animals also can be actors in strategic interaction and that humans also can be prey (see also Plumwood, 1995), involves a move away from psychological terminology (being merely exposed) and toward social terminology (being opposed). We are dealing with a mutual assessment in which the opposed actors evaluate their best course of action by being aware of the other's possible courses of action and of the other's thoughts about one's own moves (Goffman, 1971, pp. 100–101). This requires making rational decisions "concerning the desirability and advisability of various courses of action" where "both assessment and decision-making depend on related capacities of intelligence, such as storing experience of events and making this experience available when it is relevant" (Goffman, 1971, p. 86). Successful strategic interaction involves mentally exploring potential programs of action while keeping the other's possible "moves" and reactions in mind.

Moves are central to the strategic interaction framework because "in a game of strategy, the world is changed by each move" (Ibid, p. 144). Goffman also uses the notion of *turns* for moments when one has the opportunity to make a choice, adding to the metaphor of interaction as a game. Actors are labeled as *players* who can be members of a *party*, i.e. when groups of players have a common interest. Opposing parties can establish temporary *coalitions* if they have an interest in common. Examples from military affairs and spying are taken up several times in the essay, perhaps exaggerating the gamelike and competitive aspects of interaction. He also talks about *operational codes* to account for the part of the game that involves "diffusely influenc[ing] how the opponent plays" (Ibid, p. 95), and uses the term *information state* for the knowledge that others have of their own and their opponents' situation. The most important player attribute is labeled *gameworthiness*. This refers to the ability to assess courses of action and grasp the entire situation, also from the point of view of the opposing parties (Ibid, pp. 96–97). Special importance is also given to the opponents' *resources or capacities*, namely "the stuffs the other as a party can draw upon in his adaptations of the situation" (Ibid, p. 96). However, Goffman never ascribes the same importance to artifacts as ANT does, even if he states that the framework can account for "almost everything that is considered under the ill-defined rubric of'interaction'" (Ibid, p. 137). Strategic interaction makes it also valuable to understand non-dyadic interactions, e.g. communication systems. These are non-dyadic "channels, relays, nets, transmitters, receivers, signals, codes, schedules, information loading" (Ibid, p. 140), which regulate and maintain information in an organization.

In sum, the ANT approach to understanding power includes the involvement of artifacts and technology, in terms of either programs and anti-programs (Latour, 1991) or the modern Machiavellian prince (Latour, 1988b). This also means that the interactional arrangement does not necessarily imply the co-presence of the actants. In that sense it deals with forms of interaction that are both non-dyadic, as more than two entities are in focus, and indirect, as the interaction where "things" are included in the analysis can be performed asynchronously. However, Goffman's notion of strategic interaction, like that provided by Machiavelli (1513/1966), better highlights the calculative thinking and gamelike aspects of interaction where rational decision-making and strategic moves are of special importance. It adds a detailed focus on the gamelike aspects of interaction to our model. ANT in that sense is rather sparse in this regards, as it concentes on the sociotechnical complexity and significance of things in an analysis of power, rather than on the strategies deployed.

4. Method and setting

Our aim is to analyze and conceptualize non-dyadic animal-computer interaction. We are specifically interested in interaction that is "natural" and ordinary, and that includes other animals than pets. We attempt to provide a conceptual and generalized understanding, which also can be generative for design.

Our case involves both wild animals and new types of technology. The choice emphasizes a diffuse and compound type of interaction that stands in contrast to the already established forms of interaction within ACI. The empirical case is generative per se, because the unit-of-analysis is previously unexplored. But also because of the case's complexity, which requires new types of generalizations and conceptualizations. We suggest that this aggregated level is where new design ideas can be generated, rather than the detailed level of improving boar hunting. In the following, we explain the method, setting and technology involved in the case study.

Table 1.
Overview of the hunters, type of camera station and type of camera.

Hunters	Type of location	Type of camera
Mikael	1: Bait station	1a: Memory card
Jon	2: Bait station	2a: MMS
	3: Game trail	3a: Memory card
	4: Game trail	4a: Memory card
	5: Bait station	5a: Memory card
Jens	6: Bait station	6a: MMS
		6b: MMS Panorama
	7: Feeding station	7a: MMS
Anders & Knut	8: Bait station	8a: MMS
Sven & Anton	9: Bait station	9a: Memory card
Markus	10: Feeding station	10a: MMS
	11: Feeding station	11a: Memory card
	12: Feeding station	12a: Memory card
	13: Bait station	13a: MMS
	14: Bait station	14a: MMS

4.1. Ethnography and interviewing in context

The interaction is studied through ethnographic fieldwork, including both interviewing in context and observations.

4.1.1. Fieldwork overview

The fieldwork took place between December 2013 and April 2014 and included six visits to different hunting grounds. In total, it involved eight hunters (normally the hunting leader, and on two occasions also a member of the hunting team) and visits to fourteen different "camera stations" and fifteen cameras (as there were two cameras at one of the stations). Table 1 provides an overview of the respondents and the "camera stations" we visited during the fieldwork. Most of the hunters used several cameras that were moved around between different strategic spots. In only two cases did the hunters have only a single camera in their possession (i.e. Mikael; Sven & Anton, see Table 1). All other respondents had several cameras, however not all of them are included in the fieldwork. The visits, which were recorded, varied between three and four hours, except for a single interview that lasted for two hours. In total, the data consists of around 890 min of audio and video recordings. The hunters are anonymized in the findings and analysis.

4.1.2. Out in the woods

All the visits involved visiting the locations where the cameras were installed "in the wild" where the hunters described and demonstrated the ordinary activities related to the camera. Pursuing such a "camera route" was a regular activity for the hunters. At each stop the hunters showed us the ordinary activities related to trail camera hunting, such as replacing/emptying memory cards, changing batteries, investigating animal tracks on the ground, tarring trees, resupplying feeding stations, and laying corn-bombs. Some maintenance activities could also be done remotely, especially if the hunters used MMS-cameras. Then they could check

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battery status and whether the images on the memory card were beginning to be overwritten by new images. The hunters guided us and we asked them to describe everything they do in relation to the cameras. This obviously also included looking at the images and going through the "visual catch" on a tablet or laptop that the hunters brought with them. In one case, this was done on a larger scale at the hunter's home in front of the computer, where a series of over a thousand images was discussed.

There could also be spontaneous stops between the camera stations, for example if the hunters saw animal tracks on the ground. Some parts of the fieldwork were conducted during winter, when tracks are more easily detected. The fieldwork was conducted during daytime when the boars are hiding in the forest. The fieldwork did not include the actual rifle hunt, which in this type of hunting takes part when twilight has fallen. However, when talking about the cameras the hunters also brought up experiences and stories relating to this part of the hunt, as the camera has an important function to play there as well.

4.1.3. Limitations and sampling

The study is limited to Swedish hunters and their use and experiences of trail cameras, which in turn are focused on inventorying and organizing the hunting of wild boars. It became evident that the cameras captured images of many other species as well, both intended and unintended. But we have chosen to delimit the analysis to wild boars, as they make up such a large part of the activity. Moreover, the study takes its point of departure in the hunters' perspectives on trail camera hunting by "following the actor," a central approach within ANT (Randall et al., 2008, p. 107). In this case we have followed not only the hunters, but also the cameras. The boars have only been followed through the images taken by the hunters and through the hunters' stories, knowledge and experiences of boars and their behaviors and movement patterns. The participants were sampled from online hunting forums by searching through threads for discussions concerning trail cameras and trail camera images. Hunters involved in trail camera talk were invited to participate in a private message describing the study.

4.1.4. Coding and analysis

The recorded material was transcribed and coded by the team in two stages. The first coding phase was an iterative process that progressively developed in parallel with the fieldwork. In the first phase the coding was inductive and descriptive, in order to obtain an empirical account of respondents' use and experiences of the cameras on a level close to that of their statements, without any theoretical abstraction. The codes and the associations between them were explored, and the codes were categorized into different groups and themes. Based on this descriptive overview of the complex activity as a whole we decided that Actor-Network Theory (ANT) could be useful in describing and understanding this on a more abstract and theoretical level. This was followed by a second, more deductive phase, where the coded material was examined and translated with a theoretical lens prompted by ANT. The principle of ontological symmetry, according to which both human and non-human actants (in this case boars and hunters) are treated equally and are understood within the same conceptqual framework, has influenced our presentation of the findings in terms of programs and anti-programs. The presentation is also influenced by Machiavelli and his classic text *The Prince* (1513/1966), which takes the form of a set of strategies for a prince to gain and maintain power over his people. In our case, the strategies are written from both the animals' and the humans' perspectives.

4.2. Mobile proximity sensor cameras in hunting

Hunters and prey are immersed in a landscape where technology plays an increasingly important role. Radio communication has long been used by hunting teams to organize their hunt (Juhlin and Weilenmann, 2008). It is also common to equip hunting dogs with GPS-trackers to enable hunters to follow the their movements, and hence also those of the prey, on a screen (Juhlin and Weilenmann, 2013). In recent years, we have also seen an increase in the use of mobile proximity sensor cameras equipped with MMS-modules. In hunting, these cameras are usually called trail, game, or scout cameras.

The cameras add a visual dimension to the hunt, and the images can be defined as a supplementary "visual catch." Within animal ecology studies and wildlife research, cameras have been used and improved for decades as a research tool and method (i.e. camera trap survey) for monitoring various animal species in their natural habitat (Kuchera and Barrett, 2011). The idea of camera trapping can be traced back to the camera hunting movement in the late 1890s and early 1900s. These photographers understood their activity as hunting – stalking wild animals with a camera instead of a rifle, and shooting images that also served as trophies. Adapted from ordinary hunting techniques, they developed photographic blinds and the first camera trap using trip wires in order to blend into the environment and make the animals possible to see by hiding the observer (Brower, 2011).

The cameras are relatively small and easy to carry and mount on trees with a strap (see Image 1). A wide array of models and brands are available on the market. Most cameras are equipped with a passive infrared (PIR) sensor. The sensors' detection zone can vary in range and width, from wide and short to narrow and long. Systems with panorama cameras can have up to three PIR-sensors with a combined detection angle of 150°. The cameras normally take still images but can also record video. The images are saved on a SD-card. Most models have MMS-modules that either send images over the cellular network to one or several users (mobile phone or email) or directly upload them to a website. The images include a date and time stamp, battery percentage, temperature in degrees Celsius, phase of the moon, and camera ID (see Image 2 for an example). A small screen, usually on the back of the camera, is used for displaying images and settings. Hunters try to increase network connectivity by adding extra antennas. The cameras are normally equipped with an external power source, such as solar panels or a 12 v battery, apart from the

Image 1. Mounting of mobile proximity sensor camera on a tree.

Image 2. Examples of typical trail camera images of wild boars.

AA or C battery packs they usually run on. The flash is usually infrared (IR), or black (invisible) IR.

Typically these cameras are installed in front of feeding or bait stations, or along a game trail, to capture images of wild animals as they enter the sensors' range. The most common location for cameras is at bait stations. They are characterized by small portions of food, tarred trees, some sort of light source besides the camera flash, and a strategically placed blind or shooting hut, usually located in the dense forest. The cameras can also be mounted on feeding stations, which then serve as a complement to the bait station. The animals are always protected here; the automatic feeding machines distribute larger portions, no shooting is allowed, and they are usually located in more open areas. They are also moved from place to place, and sometimes the hunters test new locations and build up new bait or feeding stations. The cameras capture all kinds of wild animals, both intended and unintended from the hunters' point of view. However, wild boars are the main target, because they are very cautious animals making it difficult to estimate their numbers without the cameras.

5. Findings and analysis

In this section we focus on how the hunters and the boars relate to each other and interact in a competitive landscape that includes mobile proximity sensor cameras. They do so by following programs each consisting of a set of strategies. Following the ANT principle of ontological symmetry, we present these opposed sets of strategies in two separate sections. First, we analyze how hunters deal with the visual dimension contributed by the camera and their strategies for getting the boars in front of the camera, as well as for how to control the wild animals. Second, we analyze the boars' anti-program and their strategies to enable them to eat the food provided by the hunters while avoiding being killed.

5.1. *The hunters' program*

In general, the hunters use the proximity sensor camera system as an inventory tool for quantifying and categorizing wild animals as protected or prey, and adapt the hunt thereafter. It is also used to organize the hunt by keeping track of the boars' visiting patterns and facilitates the hunters' game management tasks. In the following, we describe a series of tactics to get the pigs in front of a camera.

First we discuss how the technology provides for prolonged watching, both temporally and geographically. Second, the captured images can be arranged to create temporal patterns, geographical patterns, and flock patterns. Third, the technology allows strategies that depend on distinguishing between individual animals and that build a relational bond between game and hunters. Fourth, it allows hunters to broaden their network of allies among hunters, farmers, and family.

5.1.1. *Watch while leaving as little trace as possible*

Hunters need to entice and convince the boars to get in front of the bait station and the camera, despite the risk of being shot. Attracting them, providing them with food, and creating an environment they accept are key to hunters' enticement strategies. Thus, hunters need to be active in the area but also to keep away from it. Part of the feeding task is delegated to machines that automatically portion out the food at specific times decided on by the hunters. In combination with a MMS-camera, feeders drastically reduce the hunters' presence in the forest and thus minimize traces of human scent that make the boars suspicious. With the new technology, they can now observe from a distance. As Markus reported:

> *We don't want to be here frequently, because you leave your scent. The effect should be "we want food." As soon as they get here, there should be something to eat. That they get a reward for all this. That they like being up here … It's mostly to attract them in order to estimate the population.*

The technology provides for prolonged remote observation. It strikes a new balance between the necessity to intrude into enemy territory and to avoid impacting on it.

5.1.2. *Keep an eye on the territory as much as possible*

Before the introduction of trail cameras, hunters only could see what was going on at a bait station when they were present themselves. With the new technology, the hunters delegate the scouting activity to the proximity sensor, which has much more time to do the job. As Knut stated:

> *If you just drive out there and sit there, then you just see what's there at that time. [With the new technology] you've learned so much, seen pigs, and such. There can be more pigs there than you thought, because you're watching the whole time.*

To extend the time that the bait is observed, the hunters enter into an alliance with a non-human proximity sensor. The system becomes an additional member of their hunting team. It is always on duty and scouting for wild animals. The sensor tells the camera when to take an image and the latter captures information on who is in front of it and how many of them there are. The memory card saves the information. Together, the sensor and the camera act as a visual logbook and a temporal prolongation of the watching.

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5.1.3. Scout opponent territory carefully to reveal geographic patterns

The hunters deploy several cameras at the same time, though not as many as would be needed to cover all their bait stations. To understand what is going on at each station, they need to move cameras around. This mobility reveals geographic patterns. As Markus said:

> *If you move the cameras around, then you might see the same sow. You start recognizing them if they walk between bait stations, which they do. If they start coming here, then it becomes their bait station. Then they might disappear. If we hunt with dogs, they may be gone for a long time… up to six weeks… other groups can visit. Then they are back again.*

Several viewpoints reveal patterns in the boars' habits. Physically moving a camera between different stations is a way to visualize how the boar moves between locations. Although this mobility of the camera is the responsibility of the hunter, it also provides opportunities to get additional information on the pigs and their movements, instead of observing visiting patterns at only one single location.

5.1.4. Reveal opponents' temporal habits and adjust to them

The logged images allow the hunters to look at the wild life not only at a later time, but also at several moments in time during one viewing occasion. The images are examples of what Latour calls immutable mobiles, i.e., objects that "have the properties of being mobile but also immutable, presentable, readable and combinable with one another" (Latour, 1986). If keeping watch is delegated to the proximity sensor and looking is delegated to the camera, the combination of these immutable mobiles becomes a visual logbook of the wild boars' visits. In front of their computers, the hunters can look at all the images from the same day or a series of days. They analyze the images and estimate the size of wild boar populations and what kind of pigs they have on their hunting grounds. Such associative work establishes patterns that were not established before.

For example, the cameras are used to keep track of boars and their visits to the feeding station. All hunters argued that the animals are both punctual and unpredictable. As Jon put it:

> *If a pig is here one evening, then he will most likely come here tomorrow as well. But it isn't certain that they will come three days in a row. Some pigs could certainly continue to visit. Then one fine day, he gets something else in his mind. Now I'll run around and check out this area. Then he changes area. Perhaps he gets disturbed or something. They are very sensitive.*

The boars' punctuality was exploited as a resource for organizing hunts. If a hunter or other member of the team lived far away from the hunting ground, by assuming a visiting pattern he or she could make sure to arrive before the boars were expected to show up. Jens stated:

> *In a way it becomes more efficient, because you can see… wild boars are very punctual. You can see [pointing to a photo] that they were here between eight and ten in the evening. That means you don't have go out at five to sit and wait. It's good enough to be there at seven. You make your hunting and the time you spend in the forest more efficient. In the end, it still depends on natural conditions, like weather and wind.*

The regularity of the boars' habits, and the recognition of it through the photos, increases the hunters' success rate. But at the same time, there are also uncertainties such as natural conditions and, as we will explore later, the wild boars' anti-program and strategies for outwitting the hunters.

5.1.5. Use the prolonged presence to reveal flock patterns

The size of a boar population is difficult to estimate solely by looking at the traces they leave behind on the ground. As Markus said: "*it looks so grubbed up. They leave a lot of traces. You could easily think there are more of them than there are.*" A single animal can be counted several times. A logged image allow the hunters to look at new details in the animals' encounters with the camera. Estimating the boar populations with the help of the camera images puts one at a great advantage compared to physical inspection of the soil. Detailed investigations of images can reveal the size of a group visiting a station. As Jens explained:

> *There are six pigs on this image, and there are six of them on this image as well. But there is only one black-and-white [pig] on that one. So, there are more than six pigs here, seven at least… Often you must sit like this and browse back and forth to get an idea.*

The hunters need look at the images, often going back and forth, and compare them with each other in order to categorize them and figure out how many animals there are in total.

Importantly, the use of trail cameras not only delegates a former human task to technology, but also restructures the program. First, the cameras oversee the area at times when no humans would be at the site. Second, analyzing patterns by juxtaposing images taken at different times is a new task that is created for the humans by the technology, or, in other words, that is delegated to the hunters by the cameras.

5.1.6. Understand and care for your opponents

The new technology is used to understand game and distinguish between individual animals, and even to develop a sense of taking care of them.

It is essential to identify the sex of the animals, because sex is a key criterion in categorizing the pigs as legitimate prey or protected animals. For example, sows are protected, as they are important for reproduction and the establishment or management of the wild boar population. Thus, cameras assist the hunters in these tasks and in making decisions. As Anders stated: "*It is an effective way to keep tabs on the pigs, so that the right animals get shot*". Before the use of the cameras, this was extremely hard, even if they went out there to shoot the boars. As Jon stated; "*you can determine their sex, or at least try, like this pig I shot. Being sure it was a boar* [male] *wouldn't have been so easy out there in the dark, but this time I knew it was a male boar.*" In areas where these animals are hunted they are mainly active at night. That makes it hard to identify their sex in a dark and dense forest. Deciding on the sex of the boars by looking at an individual image requires interpretative skills, as Jens exhibited when interpreting the sex of the animals by looking at images on the screen:

> *Here are some pigs. If you look at this one, it's very large…. This is a male. You have the brush [male genitals] and a steep sloping cross… The camera is located a bit too far away, but I think this one is also a male. It's more like a male… This one is probably a female. If we look at the shape here. Males have more jagged silhouettes. Females are rounder in the back.*

Categorization work depended on images of the animals' silhouettes. Hence, the task is similar to that of estimating the size of the population.

The greater possibility to watch over time and at a distance also affects the relationship between hunters and boars. Hunters develop emotional ties to some of the animals. This occurs because hunters provide the boars with food on a regular basis and may see some individuals often enough to be able to identify them. Then they begin to feel some kind of connection with the boars. Jon said:

When you get the images of the pigs… You think that they're your pigs. You want to feed them. You want to take care of them. But then you shoot them. In the end that's what it's all about.

The relationship between hunters and wild animals grows when hunters look at images of the animals and learn to recognize them as individuals. The hunters begin to care for the boars. It is an ambivalent relation, because they still enjoy the hunt. The strategy is to ally themselves with the enemy, and give them what they want, to achieve their goals. The consequence however, is that they lose their instrumental attitude and become somewhat emotionally attached.

5.1.7. *Recruit allies to work for your benefit*

The technology allows the hunters to establish new forms of collaboration. It was common to share images on various online hunting forums, or hunting groups, to ask for help and expert advice in categorizing pigs. As Jon said:

You have the camera to see your wild boars. If you check online hunting forums, people post images there and ask other people [hunters]: What sex is it? How old do you think it is? How much does it weigh? There are plenty of groups on Facebook as well where people publish these things.

Delegating the work of looking to the cameras generated immutable mobiles, which made it possible for a hunter to make new human alliances and delegate part of the work of categorization to them. Thus, the need for humans decreases in the woods, but increases at other locations.

5.1.8. *Please those on whom you depend*

Hunting is intermeshed with other activities and depends on networks that extend to families and farmers.

By using MMS-equipped cameras, the hunters delegate the task of walking out into the forest and downloading the files on the memory card to the mobile network. This can be seen as a way to further reduce the time spent in the wilderness. Instead a hunter can be at work or sitting at home on the sofa, but still have the chance to hunt. Jon explained the difference between cameras that log the photos on a local memory card, and those that also instantly send the data over the mobile network:

It's totally different. I can live in my hobby. I can spend time on my interest even when I'm at home, as a parent with young children. When I'm sitting at home on my sofa, then it's a blast to receive the images… I can be active in a completely new way. Before, when you had a camera that didn't send the images, then you just sat there. And so you didn't care about it when you were at home. Now, you sit there with a higher pulse… If I didn't have the MMS-camera, then I would have go out there to see if they are there. And it's quite a distance to travel… I have to get lucky to be there and empty the camera at the right time. Then I might not check the camera for a week, and it can be too late.

The MMS technology, which transfers the images directly over the mobile network, increases hunters' advantages over the boars by reducing the risk of missing when the pigs are there, or recently have been there. At the same time, it makes the hunters stronger since they can please their families at the same time.

The bait stations (and cameras) could be located at strategic places to steer the boars away from fields and crops, where the animals can cause a great deal of damage. Visiting a brand new spot, with tarred trees and corn spread on the ground by hand, Jon investigated the tracks on the ground, to make sure that they were from boars. Unfortunately, the camera did not take any pictures, since his older hunting buddy had put it in test mode. Jon said:

Where we have the feeder today, there haven't been many pigs. No pigs at all. It could be moved up here. Often you want to steer the boars, so that you keep them far away from the crops.

He wanted to establish a bait station at this test location that the wild boars seemed to accept, and temporarily close the other station. It is not just about pleasing the boars, but also about pleasing the farmers or landowners from whom they lease the hunting ground. They want to direct the animals away from the crops where they could cause a great deal of damage.

There is more to hunting than just killing food and putting it on the table. A wider spectrum of strategies are needed in order to please a multitude of allies. The hunters are caught in the middle of a duplicity where they do what they can to please and make allies, but lose sight of the purpose of killing boars. It is a complex game where they can delegate some of their previous tasks to the new technology, but at the same time it re-delegates new tasks to them. When associating all activities, we see a heterogeneous network including hunters, farmers, families, boars, sensors, bait stations, and a number of strategies. Manifold interactions are occurring, most of which seem indirect and vague.

5.1.9. *Do not underestimate your protagonist*

The last strategy provides a framework for understanding the other strategies above. In several of the strategies deployed by the hunters, the wild boars are presumed to be different than humans, but still intelligent. As Anders said:

One funny thing about the boars is that they eat acorns, and there's tannic acid in oak trees: That's not good and they have to do something about it. They grub grass because couch grass neutralizes tannic acid. It's peculiar; it's evolution, thousands of years of development. Cows and such, they get high on acorns when they eat them; they can even die from it. But the boars, they've understood how to deal with it. They're not so dumb. They say that the boars are smarter than a dog. Well, it isn't a dumb animal you're dealing with. It's a challenge. They learn things.

Most importantly, this framework recognizes that boars have strategies to handle problems. The wild boar is an animal that adapts to its specific situation, and that capability needs to be recognized. Anders's explanation of the nature of this capacity seems ambiguous. He claims that such strategies have evolved over thousands of years. The intelligence is thus to be found in the species adaptation. But he also claims that an individual animal is smart, and has the ability to adapt. Despite these ambiguities, the underlying idea of this strategy rests on respect for the boar.

Wild boars do have senses that differ from those of humans, which makes it challenging to establish bait stations. New stations are preferably located along what hunters believe to be game trails. Such trails can be identified by looking at tracks on the ground or physically spotting animals. Anders reported that then they would sometimes "*…paint a tree with tar, and throw some corn on the ground*" and then mount a camera, just to see if the animals return. Jon stated:

We placed it [a bait station] at what we thought could be a good spot, because I know the pigs used to be fifty meters away. But they didn't dare to come. It can be for some strange reason, unknown to us human, like a magnetic line. Or it smells uncomfortable… They had been lying in this spruce plantation, just nearby. The wind has just blown down there. They must have caught the scent of tar and food, but they still don't go there… They can be sensitive. The pigs might not like being at this location… They are funny. …It may help if I move the camera twenty meters; then they might come right away.

Hunters must recognize not only that the boars are clever, but also that they have sensory abilities that differ from ours. Thus, hunters' strategic interaction recognizes the uncertain and complex nature of interaction with animals.

In sum, the hunters delegate the task of being present and attentive to the mobile proximity sensor camera in order to observe their opponents without being detected by the boars' olfactory system. The strategic use of several mobile proximity sensor cameras, placed on their hunting ground, along with series of captured images, produces knowledge about their opponents in terms of their temporal, geographic and group patterns. The increased visibility of the boars, together with the fact that the hunters provide the boars with food to attract them, builds a relational bond between the hunters and the game. Hence, the hunters are trapped in a duplicitous situation where they must sometimes please the boars and sometimes kill them. Apart from the boards they must also please other actors, such as landowners, their family, and members of other families. Their game comprises battles on many fronts.

5.2. The boars' anti-program

In this section we focus on the wild boars' interactions with the bait station, the cameras, and the locations where they are installed, as well as their different strategies and tactics for getting food while at the same time avoiding danger. The boars use hunters and delegate tasks to them, such as the provision of food. Obviously this includes uncertainty and danger, namely to eat what the hunters serve them without getting killed. They engage in a series of strategies or tactics such as avoiding the smell of humans, advancing in darkness, using individual scouts, and assuming patterns in hunters' habits.

5.2.1. Be careful of the smell of humans

Wild boars avoid the human smell as much as they can. According to one of the hunters, *"a pig has eight hundred more olfactory receptors in its nose than a dog. They have a pretty good sense of smell" (Anders).* Their well-developed sense of smell is used to detect humans, both when they are present and when they recently have been there. As Markus reported:

> *We don't want to come here so often, since you leave a scent here … Now that we've been here today, the pigs may not show up tonight because it smells like humans. A few maybe, but many avoid it. Every time we've been here during the day, there's usually not so much activity at night.*

The hunters may be equipped with proximity sensor cameras, but the pigs are equipped with a highly sensitive nose that is used to stay away from places of recent human activity.

Old male boars walk around the food and the location of the camera, before making a move towards it. The circular walk is used to investigate the site and identify possible enemies by smelling a location from all possible wind directions. Markus stated:

> *Often they walk a lap around, because, then they have sensed the wind from all sides. Then you are discovered, even if you think you've place yourself right and the wind is coming from the other side. You think that he might come from that direction, but he walks in a circle around you.*

Such boars are said to be the most cautious; i.e. *"they've grown old for a reason"* (Markus). Even if the hunter puts a lot of effort in finding the best strategic location by taking into account the wind and the typical directions from which the wild boars usually enter, they are outwitted by the pigs' strategies.

5.2.2. In case of danger, advance at night

In hostile environments, wild boars almost exclusively go out on their food routes at dusk or dawn (see Image 1). On the hunting grounds, they keep their guard up. During daytime they hide in bushes and under fir branches. Male boars, which are said to be the most cautious, may also choose other places. Markus reported that; *"some of them even avoid moonlight in open areas like this one. If you hunt them during the day, then they can be lying in odd places. They can be lying alone, in crevices, instead of under a fir."* This change of the circadian rhythm can be understood as a strategy to avoid danger. It is also evident at night when the moonlight is extra strong; at such times they can avoid the camera and food locations. Knut stated that "…*when there is a big new moon lighting up the winter night, and then a cloud passes by, that's when the pigs run out and eat, and when it has passed and it gets lighter, then they're off again."* Thus, one boar strategy for avoiding danger is to avoid eating from the enemies' food when it's light out, and only advancing when protected by the dark.

Not all boars follow this strategy, hungry piglets for example, or groups of boars that feel very safe. Apart from a few inexperienced and orphaned piglets, whose only hope for survival lies in the food provided by the hunters, there are few images of wild boars during daytime. Yet, in environments where the wild boars are not attacked and there is no hunting, they can actually be active during daytime. As Mikael said:

> *You have a picture of the wild boars as shy and sleeping during the day … but it's said that they are actually alert during daytime in environments where they are left alone. When they have hunters after them, they have a different daily rhythm.*

Darkness is used as cover to stay unseen by hunters, while still eating at the bait station. The observations of young inexperienced piglets and of boars in areas without hunting indicate that hiding in darkness is a strategy chosen to balance the benefits of getting food against the danger of being shot.

It follows that the boars are attentive to light. When looking at images of wild boars or other animals, hunters reported that the animals sometimes "look back" at the camera. Even though infrared light is said to be invisible, it seems to be noticed by the animals, according to the hunters and their interpretations of the images. Anders stated:

> *This camera has something called black IR … it's invisible they say, but you can see if the animals looks at the camera when it takes a photograph; you can see in their iris, that it glistens, just as it does with a regular flash. The other cameras we have, they have red IR … they can see that the LED turns red, and then fades out, the pigs can see that.*

Wild boars seem to notice the cameras but ignore them, as they have learned that the cameras do not pose a direct threat and do not smell like humans. Anders stated that the wild boars reacted to proximity sensor camera, but *"not in such a way that they get scared. Maybe at first, but perhaps they've gotten used to it. It isn't dangerous, and nothing happens."* The animals can detect IR, but as long as it does not involve any immediate danger they seem to be relaxed.

5.2.3. Start by sending in a fast scout

When a group of wild boars visits a bait station for the first time, they are extra careful and hesitate before they advance. They might send out an individual pig to test the site and see if anything happens. Anders said:

> *They can be very cautious the first and second time they come here to explore a spot. They might go around the station for three hours before they dare to come out. And then they send someone in. Fast in, fast out.*

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The boars try to understand the situation by sending a scout into the open and unsafe area where the bait and food are located. Meanwhile, the rest of the pack waits in a denser and safer part of the forest.

5.2.4. Assume a pattern in hunters' killing

It is not only humans that assume there are patterns in their opponents' habits. Wild boars are usually especially careful in forest areas where hunting occurs, and when there have been recent killings. Knut reported; "*it all depends on how much you've been shooting. If you've been out shooting, then when they return there, they are extremely careful*". They assume that if boars have been killed once then it can happen again. The hunters also stated that the animals might return more quickly if they are hungry and are struggling to find food elsewhere. As Jon said, "*they may be gone for four months or they may come back the same night. It depends on how hungry they are and what they think happened.*" Younger and inexperienced piglets were the least shy. These orphaned piglets had to rely to the food the hunters provide them. As Anders stated: "*They don't have the experience. They can just go out and stand there. Then you can shoot a pig today, another one tomorrow, and the day after.*"

The boars' interpretation of patterns is temporal and situated. If they have experienced something bad at a certain location, like the sound of shooting connected to a kill, then they are aware that it might happen again later at the same place. The boars expect the hunters to hunt again in the same location.

In sum, wild boars are stuck in the middle of a risky game where they do what they can to avoid their enemies but still eat from the food provided to them. They are unaware, however, of the hunters' new, non-human, proxy army comprising the camera, the proximity sensor and the MMS-module that show who is there and how many of them there are, log their visiting patterns, and instantly send this information to the hunters. But just like the hunters, the wild boars discern patterns and make associations, even if they are more related to the presence of humans and history of places.

6. Discussion

We have presented an ethnography on the use of mobile proximity sensor cameras in the sport and recreational activity of hunting. Influenced by Actor-Network Theory (ANT) and its concern with ontological symmetry, we have focused on how hunters and wild boars relate to each other in a landscape where technology plays an increasingly important role, and how their actions and strategies can be understood in terms of interaction. We argue that ANT, in combination with Goffman's notion of strategic interaction, is suitable for revealing and conceptualizing complex and non-dyadic computer-mediated interspecies interactions, and that these perspectives can fruitfully be combined.

In the following we first concentrate on how hunters and boars delegate tasks to each other in a complex and gamelike interaction that obviously is about power and resistance and includes strategies and counter-strategies. We then discuss the form that the interaction takes, and how it is conducive to indirect and non-dyadic interactions. Even if we highlight design considerations along the way, it is in the final section that we most explicitly discuss the potential role and influence of ANT in the design of animal-computer interaction and user-computer interactions more broadly.

6.1. Understanding interaction as strategies, or writing the Prince of the forest

Throughout history and in different cultures, hunters and prey have engaged in game-like interactions. It has been said that they have a "sporting relationship" (Franklin, 1999). This is also evident in Goffman's (1971) discussion of the lion, which, together with its human opponent, makes assessments involving a large amount of rational and calculative thinking before making a move. This implies that each player needs to understand both its opponent and how the opponent may understand it. Hence, both the humans and the animals involved in the activity need to understand the situation broadly, taking into account their opponent's viewpoint and possible reactions to their moves. In terms of Goffman's notion of strategic interaction, they need to understand each other's secrets and strategies in order to successfully play the game. However, it is only the hunters that use technological aids, while the boars get used by that technology. Even if Goffman mentions technology as an important "resource," he does not impute the same meaning to it as ANT does when emphasizing how it can increase a player's power when included in a program of action (Latour, 1991) or in a Machiavellian analysis of power (Latour, 1988b). On the other hand ANT misses the more calculative and game-like aspects of interaction accounted for by Goffman, where rational decisions and strategic moves are of particular importance. Hence, these two perspectives complement each other, and in the following analysis they are combined.

As the findings have shown, the hunters, the proximity sensor camera system, the automatic feeders (i.e. the "camera station" as a whole), and the wild boars are associated with and dependent on each other, and can be seen as actants in a heterogeneous network. Each actant's actions are at the same time an effect of or reaction to other actants' actions, and in turn they affect the other actants and the actor-network as a whole. It is in this sense they are dependent on each other and delegate tasks to each other. The wild boars delegate the provision of food to the hunters and the automatic feeder, but on the other hand, this is part of the hunters' plan of attracting and manipulating the boars. The hunters' Machiavellian strategy is disguised as pleasing the boars. But as the boars survive the battles with the hunters, they get smarter and more suspicious. They develop strategies as part of their program of eating the food provided by the hunters while avoiding getting shot. Examples are to "only advance at night" under cover of the dark and dense forest, or to examine a possibly dangerous situation by "sending in a fast scout" before the party of boars advances and eats of the food. Another essential strategy for the boars was to "be careful of the smell of humans." Some boars could be suspicious and refuse to show up at the site even hours after the humans visited the location and left their scent, which highlights the boars' keen sense of smell. This was also apparent in that some old boars walked in a wide circle around the bait stations where proximity sensor cameras were installed, using their highly developed sense of smell to investigate whether enemies were present or the coast was clear. Another strategy to reduce the risk in dangerous situations was to "assume patterns" in the hunters' shootings and, based on their knowledge of previous events and patterns, adapt their own patterns of movement and choose other places to eat.

Among the hunters, an important strategy for dealing with the boars' counter-strategies and resistance was to "watch while leaving as little trace as possible." This was done by delegating as much of their observational tasks to the camera. As they also had to provide the boars with food and bait, they also delegated the task of refilling food or laying bait to automatic feeding stations. Maintaining a presence without being physically present was a prerequisite for visually capturing boars. Similar to the camera hunters in the 1890s, who developed photographic blinds to obscure their own presence in order to be able to make the animals visible (Brower, 2011), the camera system as a whole camouflages the hunters, and most importantly reduces their human scent, and hence avoids making the already cautious boars even more cautious. The mobile proximity sensor camera, with or without MMS, also enables the hunters to "constantly keep an eye on the territory" and to be constantly aware of what is going on. In that sense, the hunters also delegated their vision and attentiveness to the system. The connected cameras also help them implement the previously mentioned strategy of preventing the boars from sensing traces of their presence. Like the boars, they moved around on the field, but in the hunters' case they moved their additional hunting-team members, the proximity sensor cameras, between the different bait stations. This strategy of "carefully scouting opponents' territory to reveal geographical patterns" was also evident in the fact that most of the hunters used several cameras tactically placed on one of their bait or feeding stations on their hunting ground.

The images, or immutable mobiles (Latour, 1986), constitute a visual log of the boars' presence at the bait stations. This log is saved on a memory card that the hunter must go out and fetch, unless that task is delegated to an MMS-module. The time-stamps on the images provide the hunters with important information. By knowing when and for how long the boars usually spend time at a spot they could both "reveal and adjust to the opponent's temporal habits." This allowed them to organize and plan the hunt more effectively, but nevertheless they often could be outsmarted by the boars if their scent was detected by the boars in the final phase of the hunt. The more experienced boars were even more sensitive and developed more advanced strategies. Hence, to the hunters the boars were both predictable and erratic at the same time. In that sense, in order to be successful, the hunters must be sure not to "underestimate their opponents" by recognizing that the boars are clever and having respect for their sensory abilities.

Even if the mobile proximity sensor camera system as a whole can be seen as an extra team member working for the hunters, it in turn delegates a completely new set of tasks to the hunters, such as to "reveal patterns in groups" and "recruit allies to work for your benefit." This highlights that most tasks also can be conceptualized as strategies. In addition to performing technical maintenance (changing batteries, emptying memory cards, hooking up extra power sources, dealing with bad cellular coverage), the hunters must look at the images, analyze and interpret them to determine what kind of boars and how many have been caught on camera, and adapt and organize the hunting thereafter. The system adds a visual, and also a technical dimension to the practice. However, it is only the hunters that delegate tasks to technology, giving them greater power and advantage. By delegating the act of observation to technology, and thereby masking their scent, the hunters manipulate the boars by giving them a false sense of security. Hence, the proximity sensor camera represents a kind of machination against the boars, who are unaware of the invisible hunter and his delegated presence. The hunters need to "understand and care for the opponents," which means to enter into an alliance with the animals and serve their needs; but ultimately they intend to kill them. Hence, the empirical findings revealed a duplicitous attitude. The boars, on the other hand, want to eat the food provided by the hunters, but at the same time want to avoid being killed. Even if they are unaware of the invisible hunter and his delegated presence, they develop strategies to deal with more immediately dangerous situations. Instead of a proximity sensor and a camera they have a highly developed olfactory system.

The inability to include objects in social analysis is central to Latour's critique of sociology. He claims that "studying social relations without nonhumans is impossible or adapted only to complex primate societies like those of baboons" (Latour, 1988b) and "whenever we discover a stable social relation, it is the introduction of some non-human that accounts for this relatively durability" (Latour, 1991). This also seems to be true of our relations with animals. Artifacts such as leashes, bridles, aquariums, etc., always seems to be involved in the domestication of animals and places where we have more stable human-animal relations. Objects, artifacts and technologies are intertwined in our social world to such an extent that we sometimes are unaware of the tasks we have delegated to them. One of Latour's many examples concerns human-animal interaction, namely the interaction between shepherd and sheep, where the task of containing the flock is delegated the fence rather than being done by shepherd himself (Latour, 1996). The interaction presented here does not include physical boundaries as with Latour's fence. Still, as highlighted in Fig. 1, when mobile proximity sensor cameras are introduced they gradually stabilize the boar-hunter interaction and this leads on to

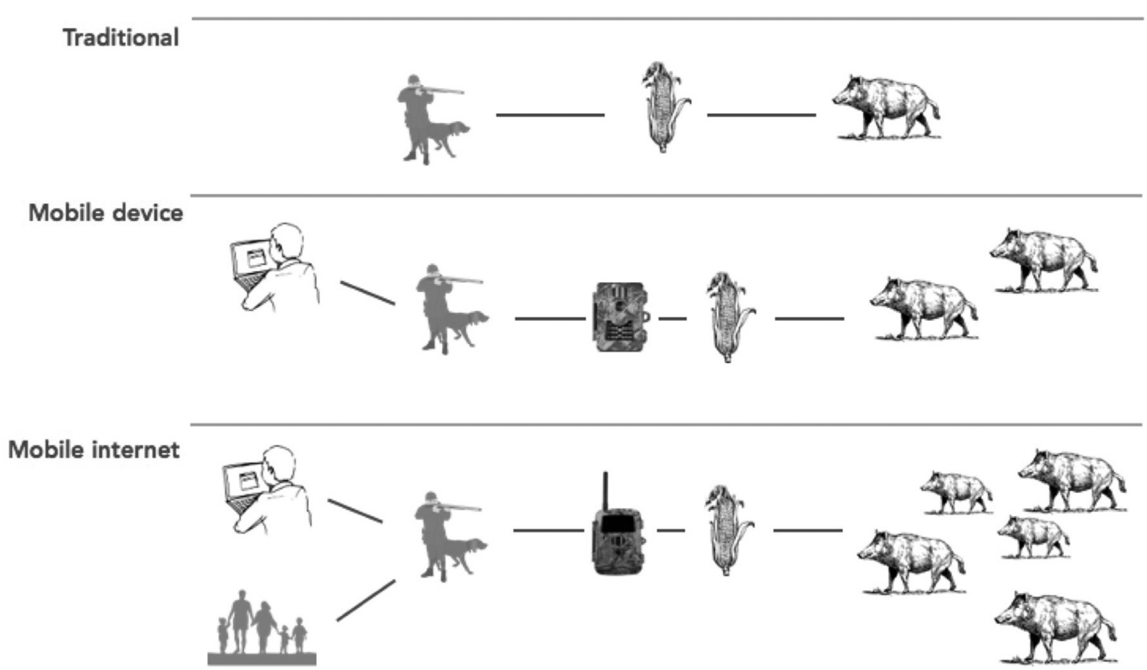

Fig. 1. Different scenarios describing the increased involvement of actants with the addition of new technology.

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"a new situation" in the sense discussed above, with new relations, strategic "moves" and delegation of new tasks. This assembly is increasingly stabilized and wide-ranging in terms of number of involved actants when MMS technology is added.

Furthermore, the delegated tasks are more complex and manifold. They even reconfigure the interaction by *prescribing* a completely new set of tasks for the hunters (e.g. maintaining the camera, analyzing images). However, the mobile proximity sensor camera system does more than just prescribe a new set of tasks for the hunters. It also emphasizes a new spectrum of approaches to the animals, other hunters, the hunters' families, farmers and landowners. The involvement of the camera involves the hunters in complex considerations in terms of pleasing themselves as well as the many other actors with interests and agendas of their own (even if they to some extent are in alignment with the hunter). The hunters are involved in several simultaneous battles on different fronts, and they must "please those on which they depend." They must please the landowners and farmers by keeping the boars from damaging the crops. Because the mobile proximity sensor camera connected to the internet brings the hunt and the boars into their homes, and even onto the living room sofa, they must also please their families by not letting the hunting get in the way of family life. They must also please the boars by providing them with food, attracting them to the hunting grounds, and keeping them alive, while at the same planning to kill them. In that sense, a hunter must be Machiavelli.

Design consideration: Look beyond concrete and immediate situations and conceptualize the bigger picture by viewing animal-computer interaction as strategies of both animals and humans that can coagulate as durable relations.

6.2. *From dyadic and direct to non-dyadic and strategic interaction*

Our main question has been to understand the notion and role of interaction in animal-computer interaction. How to understand interaction between humans and computers has been a long-standing concern in HCI. The idea that the important features of interaction take place in the mind has been challenged, and it is increasingly thought that both context and multi-person collaboration matter. The idea of interaction as occurring as cognition is obviously getting challenged when accounting and designing for interaction that includes non-human species. A critical topic in ACI concerns how to model or articulate non-language-based interaction, such as that occurring between animals. Previous research (Juhlin and Weilenmann, 2011; Mancini et al., 2015; Aspling and Juhlin, 2015) addresses this problem by scrutinizing details in ongoing and temporally unfolding non-language-based direct interaction, such as sniffing, barking, or being connected to a human by a leash. However, the use of trail cameras in hunting involves another type of interaction that is more diffuse and complex. The technology mounted in the forests is not interacted with in an empirically available and sequentially unfolding indexical interaction that can be analyzed using an ethnomethodological approach or through detailed scientific analyses of video recordings or sensor log data. Instead, humans and non-humans are relating to each other and interacting in a more asynchronous way. Hence, compared to conventional ACI, where the focus is on synchronous interaction between an animal and a computer (Fig. 2A), our case highlights a different scenario. The interaction, as we have framed it, is performed and distributed over a much longer time-span and all actants with their different goals and strategies are symmetrically involved in the interaction model (Fig. 2B).

We have already shown how the two opposing parties delegate some of their actions to each other, and in the hunters' case also to technology. This framing of interaction as a battle between the two species highlights a strategic dimension, but also that the interaction is indirect and non-dyadic. It is perhaps most direct in the final stage of the hunt (which also is left out of the analysis), but the process leading up to it is a complex set of actions that are acted out when the actants are separate from each other. In that sense the interaction is more complex than direct and dyadic interactions, where the focus is on synchronous interactions between the animal and the computer.

The interaction is *prolonged* in time because we rarely see any direct interdependence between "cause and effect," i.e. between the mounting of a camera and actions performed by the boars or the hunters. The most direct strategy perhaps occurs when hunters "please those on whom you depend," i.e. when a hunter gets an MMS while sitting on the family sofa on a Friday evening, and waits until the rest of the family has gone to sleep before leaving for the woods. The interaction is also *networked,* since it is hard to distinguish a bounded item interacting with another individual. For example, several items in the area, such as trail cameras, human scent, and the previous history of actions by many, seem to influence another indistinguishable network, e.g. a group of animals. Further, the interaction is *heterogeneous,* since it is made up of combinations of humans, other species, and technology. The boars interact with their peers, the camera, scents, and visible humans all at the same time, and the humans account for technology, the landscape, and indications of the presence of non-

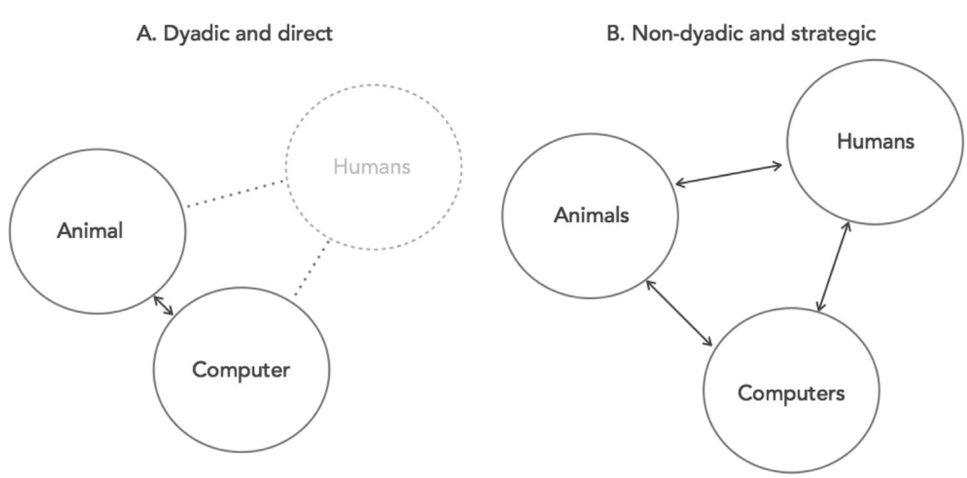

Fig. 2. From dyadic and direct to non-dyadic and strategic interaction.

human species. It is therefore important to understand the use of new technology – such as cameras with proximity sensors connected to the internet – as a form of interaction that is oriented around actor-networks influencing actions over an extended period of time.

Design consideration: In the selection of both topics and methods, acknowledge interaction with non-human species as emerging and networked.

6.3. ANT in the design of digital technology

As stated by Rogers (2012, p. 9) "the arrival and rapid pace of technological developments in the last few years (e.g., the internet, wireless technologies, mobile phones, sensors, pervasive technologies, GPS, multi-touch displays) has led to an escalation of new opportunities for augmenting, extending and supporting a range of user experiences, interactions and communications." Digital technology and computing are now touching on all aspects of human life, and noticeably also our interactions with animals, and the animals themselves. Hence, computing leaves few areas untouched, and digital technology is present virtually everywhere, though sometimes invisible and embedded in the environment. This implies that user-computer interfaces are becoming increasingly hard to define (Sellen et al., 2009). Consequently this is also a move towards more complex and diffuse forms of engagement and interaction with technology, and ANT can be a way of dealing with this complexity, whether it be HCI or ACI.

The successful use of cameras, with proximity sensors and mobile internet, in strategic non-dyadic human animal interaction can inspire other form of design that provide for prolonged, complex and multi-participant use. The case discussed is on an abstract level a combination of media technology and architecture i.e. cameras and local arrangements. Obviously, we could conceive of system that provides for other types of media, such as live video, and other local arrangements including fences, rooms etc. We could also conceive of systems including other sensors e.g. audio or temperature or other means for sharing data. All such variations and adjustments provide for alternative design concepts, which would restructure the non-dyadic interaction and support the same or new strategies. Importantly, that sort of interaction does not lend itself to lab experiments that are commonly used in the area of human computer interaction and in ACI.

Design consideration: Acknowledge the potential of mediatization to influence strategic and non-dyadic interaction.

6.4. Moral considerations

ANT is based on the idea of "ontological symmetry," i.e. that human entities should be analyzed in a similar way as non-human entities. This methodological approach has been applied in order to make hidden politics visible, not least when it comes to interaction between humans and non-human species (Haraway, 2003, 2008). Such political or ethical ambitions may conflict with an analysis of the influence of new digital technology on the hunting of wild animals, or with explicit ethical obligations for the ACI-area to design to improve animal life. However, such ambitions are somewhat orthogonal to the motivation behind this study. Since our starting-point is the notion of interaction in an activity involving humans, non-human animal species and technology, we hesitate to give priority to any type of species. In a sense, we aim to be species-neutral. Further, it seems difficult to make any a priori political or ethical judgments given that the technology seems to both hamper and help the species in the hunt. The boars try both to engage with the food presented to them and to get away from it. The hunters extend their ability to kill with the new technology, at the cost of finding it harder to shoot at animals they have gotten to know.

Design consideration: Avoid a priori simplification of design challenges as being either for humans or for non-humans, and acknowledge the existence of complex interdependencies.

7. Conclusions

Encounters between humans and animals take many forms and is performed in a multitude of ways. Increasingly these sorts of meetings involve digital technology. The whats and hows of these occurrences is both intriguing and puzzling. When research related to HCI start to take an interest, the most evident and promising approach is to study those animals that are easiest to understand, e.g., working dogs whom are most close to humans, as well as applying well-recognized HCI methods, such as the lab-experiment. This is of course reasonable, but it needs to be recognized that the selection of actors and methods disclose much of the meetings that where intriguing imagination in the first place.

Drawing on an ethnography of the use of mobile proximity sensor cameras in ordinary wild boar hunting we have exposed a diffuse and compound form of interaction. This type of interaction is not as directly observable as the pre-existing forms of interaction within ACI that most commonly are dyadic (i.e. focus on two individual entities: the animal and the computer), direct (i.e. the interaction is synchronous with a immediate connection between cause and effect) and are performed in the lab together with domesticated animals. The interaction involving hunters, boars and mobile proximity sensor cameras is distributed over time and space can only be revealed when looking at the complex comprehensive picture. Rather than focusing on synchronous interaction between animals and computers in a restricted lab setting, our study shows that interaction can also be non-dyadic and indirect, and involve wild animals. Hence, we propose that other forms of interactions are possible, and present an alternative theoretical framework for animal-computer interaction that is descriptive, conceptual, and generative for design.

By theorizing this form of interaction in the light of ANT accompanied with Goffman's conceptual framework of strategic interaction, we have exposed a gamelike form of interaction although prolonged, networked and heterogeneous. Conceptualizing it as a set of strategies opens to consider interaction in a broader sense, where single actions are part of a extended series of actions distributed over time and space. This includes calculative thinking and accounting for a variety of situations, consequences, and expected moves by the opponent. The species-neutrality of the ANT's ontological symmetry principle, in combination with Goffman's distinction between being *exposed* to danger and being *opposed* by a dangerous opponent, makes it possible to view interaction as an asynchronous game in which each species is opposed by the other in a series of mutual assessments acted out through a set of strategies and counter-strategies. It offers a conceptual framework for understanding ongoing complex interdependencies where animals, people, digital technology and other artifacts constantly affect each other and assemble themselves into heterogeneous networks. In the selection of both topics and methods, we have recommended to acknowledge interaction with non-human species as emerging and networked.

These perspectives reveal mechanisms of power and machinations, strategies and counter-strategies deployed by the opposing players of the game. These findings could be used to inspire the design of other forms of interactions and also to cast new light on pre-existing ones, such as those occurring in traditional ACI experimental settings. We have suggested avoiding a priori simplifications of design challenges as being either for humans or for non-humans, and acknowledging the existence of complex interdependencies. It does not have to take the form of devious machinations about life and death, as highlighted in the case of hunting. It can include many diverse forms of strategies. Every form of interaction with animals implies some sort of exercise in power. Even in the most friendly relations and design environments there are always princes with long-term and heterogeneous strategies.

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