The Emerging Nature of Participation in Multispecies Interaction Design

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The Emerging Nature of Participation in Multispecies Interaction Design

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ABSTRACT

Interactive technology has become integral part of daily life for both humans and animals, with animals often interacting with technologized environments on behalf of humans. For some, animals' participation in the design process is essential to design technology that can adequately support their activities. For others, animals' inability to understand and control design activities inevitably stands in the way of multispecies participatory practices. Here, we consider the essential elements of participation within interspecies interactions and illustrate its emergence, in spite of contextual constraints and asymmetries. To move beyond anthropomorphic notions of participation, and consequent anthropocentric practices, we propose a broader participatory model based on indexical semiosis, volition and choice; and we highlight dimensions that could define inclusive participatory practices more resilient to the diversity of understandings and goals among part-taking agents, and better able to account for the contribution of diverse, multispecies agents in interaction design and beyond.

Author Keywords

Multispecies Participatory Design, Training, Dogs, Animal-Computer Interaction, Multispecies Interaction Design, Volitional, Semiotic and Choice-full Engagement

ACM Classification Keywords

(Beyond) Human-centered Computing: Interaction Design, Participatory Design

INTRODUCTION

Interactive technology has become an integral part of our living environments and daily practices, not only for humans but also for other animals. In open fields [28], laboratories [38], farms [27], zoos [44] and homes [43], nonhuman animals are increasingly coming into contact with it. Either technology mediates humans' interactions with other animals [9] or animals mediate humans' interaction with technologized contexts in which both humans and animals operate [21]. To support these users, the emerging discipline of Animal-Computer Interaction (ACI) [24] aims to design animal-centered technology applying animal-centered methods [46]. To this end, some ACI researchers deem the participation of prospective animal users and stakeholders in the design process essential [20]. However, interspecies differences and resulting communication barriers stand in the way of participatory design research and practice with non-human animals. Furthermore, the cognitive capabilities of abstract thinking and expression that underpin human language have also underpinned our species' cultural and technological evolution, leading to fundamental power inequalities in the relation between humans and other animals. Such inequalities have arguably reduced the need for our species to negotiate with others the terms of human-animal interactions, making it less relevant for humans to evolve the ability of dialogic exchange with animals. In this respect, some are skeptical about the possibility of doing participatory design with other species [17]; while others argue that participatory design is possible, but only if animals are allowed to engage with technological artifacts entirely on their own terms [14].

However, much of animals' interactions with technology is constrained, in terms of the contexts in which the interaction takes place, the purposes of the interaction, and the forms that the interaction may need to take, none of which the animals involved necessarily define or choose [20]. This is typically the case with working dogs, who are required to carry out specific tasks on behalf of or in cooperation with humans, to support which ACI researchers have begun to develop a range of technologies [16,19,21,22,34]. While capitalizing on existing canine capabilities, the tasks that these dogs need to perform are not necessarily part of their evolved behavior and therefore require learning, usually through training. Even technologies designed to support working dogs in their tasks often require learning and thus training [4]. This is the case for dogs who will be operating the finished product as well as dogs who are involved in the design process. But can animals who come into contact with technology within a training context be regarded as *participants* in a design process? If so, what forms might their engagement take and what might this tell us about the nature of participation in interaction design practices where diverse, multispecies agents are involved?

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Here, we consider the essential elements of participation within interspecies interactions and illustrate its emergence, in spite of interspecies asymmetries, even within the constraints of the training process. We thus argue for the need to develop broader models of participation based on indexical *semiosis*, *volition* and *choice* and highlight dimensions that could define more inclusive participatory practices, potentially more resilient to the diversity of understandings and goals among part-taking agents. We believe that such a reframing in thinking and practice could better account for the contribution of diverse multispecies agents in interaction design and better support the co-construction of more inclusive technologized worlds.

BACKGROUND

Participatory research and practice beyond humans

Bastian *et al.* [2] point out how participatory research aspires to develop socially responsible, democratic research methods, to enable the co-production of knowledge among stakeholders. Such a co-production process is instrumental to support the inclusion of otherwise marginalized actors, enabling them to share research goals and expected outcomes, thus redressing existing power relations among stakeholders. For the authors, participatory research fosters the production of knowledge in contexts characterized by inequality and challenges existing assumptions as to what constitutes legitimate knowledge. In this regard, they note how participatory action researchers [32] and participatory economic geographers [7,8] argue for the importance of including more-than-human agents in participatory research frameworks, in order to support a process of co-learning and co-reconstitution of the world, at a time when human activity is producing drastic ecological impact.

Similarly, within the ACI community, many researchers have advocated the importance of enabling animals to actively participate in the design process as fundamental to the development of animal-centered technology [46]. On the other hand, some have expressed skepticism about the possibility that participatory design practices could be truly inclusive of non-human species. In particular, for Lawson *et al.* [17], the fact that animals lack language automatically excludes them from participating in the design process, preventing them from engaging in activities and exchanges that constitute the essence of participatory design. Since animals are unable to represent their own needs, to initiate ideas and raise concerns, and to share decision-making powers, they are effectively excluded from the design process. Unable to deny anthropomorphic projections or resist anthropocentric prejudice and devaluation, animals are thus inevitably relegated to the status of *usees* [3,17].

In this regard, Hirskyj-Douglas *et al.* [14] draw a parallel between the status of animals in ACI research and that of children in Child-Computer Interaction (CCI) research. Their Doggy Ladder of Participation is modeled on Hart's Ladder of Participation [13], representing different ways in which a child might be involved in the research process. These ways are deemed participatory or non-participatory depending on the level of autonomy and initiative afforded to the child, where at the highest 'rung' of participation the child is the initiator of decisions. Similarly, at the top rung of their Doggy Ladder of Participation, Hirskyj-Douglas *et al.* [14] hypothesize that dogs would initiate design decisions and directly influence design outcomes. For this to happen dogs would need to have an understanding of the design activities they participate in, beyond simply associating their actions with rewards they might be offered in return; and they would need to be allowed to interact with and make sense of technology exclusively on their own terms. Thus, the authors consider training, as a way of involving dogs in the design process, a non-participatory practice and place it at the bottom rung of the ladder.

However, as Bastian *et al.* [2] observe, more-than-human participatory researchers take a broader view on participation and co-production, whereby human and non-human agents are ever "*intertwined in shared worlds*" and "*both involved in the production of these worlds*". While this perspective on participation does not imply explicitly shared goals or even shared meanings, it nevertheless implies shared practices and meaning exchanges ultimately leading to co-constructed outcomes. Drawing from Haraway's notion of *becoming with* [12], this idea informs Westerlaken and Gualeni's [45] approach to participatory research with animals. The authors explore the use of physical artifacts as catalysts for interaction between humans and dogs within a playful context. The researchers' interaction with the dogs is not driven by predefined goals, but instead evolves freely and fluidly in time, along with and facilitated by the artifacts that mediate it, informed by the physically grounded actions of the actors involved.

But what about situations in which animals' interaction with technology does not take place within a playful context that allows it to evolve freely and fluidly, but is instead structured and driven by specific goals, as it is the case within training contexts? Where animals are required to interact with specific technological artifacts for specific purposes, is there scope for them to *participate* in the design process in spite of interspecies differences and communication barriers?

Use of training in multispecies interaction design

As mentioned above, much of animals' interaction with technology requires training or takes place within a training context. This is typically the case with working dogs, who are often required to carry out specific tasks on behalf of humans. These tasks might include helping people with disabilities [21]; helping during military or search and rescue missions [16]; or helping to diagnose medical conditions [22]. When reporting on the development of technologies to support the work of these dogs, ACI researchers often discuss the training process the dogs go through, either to learn their tasks or to learn how to operate the technology designed to support them in those tasks. For example, Robinson *et al.* [34] discuss the relation between the design features of a canine alarm that would enable medical alert dogs to call for help on behalf of their assisted humans and the training process that the dogs undergo to learn to operate the alarm. Mancini *et al.* [22] examine how the signaling conventions that cancer detection dogs are trained to use during the screening of biological samples can interfere with their performance. Majikes *et al.* [19] highlight how providing dogs with timely feedback during training is essential, to which end they designed a wearable vest that recognizes canine postures and notifies the novice handler, helping to improve their feedback timing. Finally, Byrne *et al.* [4] stress the importance of rigorously gathering dogs' feedback to technological interventions, for which they developed a detailed training protocol enabling them to evaluate the usability of their canine wearable vest's haptic interface against the dogs' performance. Here we are interested in the basic dynamics underpinning the training process and what these could tell us about the nature of participation in multispecies interaction design.

Training as a communication and negotiation process

Training involves associative learning, that is a combination of classical and operant *conditioning* [4, 38]. To begin with, the delivery of a reward (e.g. food) is marked by a designated signal (e.g. "yes"); this is repeated many times to enable the dog to form an association between the reward and the marker, until the dog is *conditioned* to the marker as a predictor of an upcoming event (classical conditioning). Then, the marker is used, followed by the reward, when the dog offers a desired behavior, to increase the chances that the behavior will be repeated (operant conditioning). The marker and reward are thus used to shape the complexity and quality of the animal's behavior, by gradually offering or increasing the reward for increasingly higher or more complex levels of performance. Although what is valuable for the dog is the reward, the use of the marker enables the trainer to provide immediate feedback as the dog offers the behavior, in turn enabling the dog to recognize exactly what behavior is earning him the reward. Performance errors on the part of the trainer (e.g. in timing) result in the dog not being able to establish the connection between what he does and what the trainer wants, not being able to offer the desired behavior and thus needing to adjust their response. Performance errors on the part of the dog result in the trainer not recognizing the desired behavior, not being able to mark (i.e. confirm), and thus needing to adjust the training protocol or its execution. In other words, training is an enacted communication process between the trainer and the dog, during which marker and the reward function as the vehicles of an *ongoing meaning exchange*.

This exchange can be mediated via different mechanisms, defined as *positive reinforcement* (when something of positive value is delivered), *negative reinforcement* (when something of negative value is taken away), *positive punishment* (when something of negative value is delivered) or *negative punishment* (when something of positive value is taken away) [37]. The use of punishment in training is increasingly considered inappropriate, for ethical reasons and because it discourages dogs from offering new behaviors, as noted by Byrne *et al.* [4]. Since safety is a priority over the acquisition of resources [26], for the dog whose undesired behavior is punished, offering new behaviors presents a risk of incurring aversive consequences and is best avoided, even if desired behaviors are positively reinforced. On the other hand, the dog whose undesirable behavior is ignored and whose desired behavior is positively reinforced is more likely to attempt to offer new behaviors in case these earn him valuable resources, if this comes without the risk of aversive consequences. More generally, this kind of ongoing assessment on the part of the dog informs his engagement with the training process. Just as trainers use reward levels to modify a dog's behavior and performance, so do trainees refuse to perform if they are not fairly rewarded to warrant their efforts. For example, dogs who have learnt to offer a behavior for no reward may stop offering that behavior upon seeing another dog being rewarded for offering the same behavior [30]; or they may choose to work with trainers from whom they expect to be rewarded more highly [15]. In other words, as well as being an ongoing meaning exchange, training is also an *ongoing negotiation process*, whereby both human and dog name the price of their game. But what does underpin the ongoing meaning exchanges and negotiation processes that take place during training?

Training as evolutionarily-grounded learning process

The dynamics that underpin training have an evolutionary base. Stamp Dawkins [40] points out how animals evolve adaptations to survive and stay fit in their environment, which results in them *wanting* certain things (e.g. avoiding threats to keep safe or foraging to keep fed). Discussing the evolution of canine behavior, Abrantes [1] discusses four fundamental *drives*, each characterized by specific goals, behaviors (i.e. processes) and stimuli (i.e. releasers) motivating the behaviors. The *self-preservation* drive aims to maintain one's metabolism and comfort, with internal stimuli, such as hunger, and external stimuli, such as the sight of prey, motivating behaviors such as hunting. The *sexual* drive's goal is reproduction, which results in sexual behavior motivated by the scent of a prospective sexual mate. *Aggressiveness*' goal is to eliminate competition, resulting in dominance (ritualized aggression to eliminate competition from a mate without injury) or aggression (to eliminate competition from an alien), both motivated by the presence of a competitor. Finally, *fear*'s goal is the avoidance of threats, resulting in behaviors such as submission (to group members) or flight (from aliens), motivated by the presence of a threat (an aggressor or a predator).

While drives are a constant, the *motivation* to perform a behavior that expresses and satisfies a drive is dependent on contextual stimuli and how these are perceived (e.g. when full, a wolf is less likely motivated to hunt; in the absence of threats a dog is less likely motivated to exhibit fear). Some stimuli are internal (e.g. hunger) while others are external (e.g. a predator). Some *sign-stimuli* seem to have innate meaning (e.g. newborn ducklings respond fearfully to the sight of silhouettes resembling a hawk [1]), while other stimuli only acquire meaning and become *signals* through associative learning (e.g. a clicker sound associated with food). The more a stimulus is consistently associated with an event, the more it becomes a reliable signal for it; the closest the space-temporal association between stimulus and associated event, the more reliable the signal. *Indexes*, often referred to as *honest signals* [25], are *reliable* signals as they are associated to the phenomenon they denote by contiguity (e.g. the power of a stag's roar is a reliable indicator of the animal's size). The more a sign or signal solicits fundamental drives and motivations, the higher its biological *salience* [1].

Within a learning context, signals' biological salience and reliability are important. For example, since they solicit an animal's self-preservation drive, things like treats are inherently meaningful and are referred to as *primary reinforcers* [10]. On the other hand, things like a clicker sound, while enabling a trainer to produce a reliable signal, only acquire meaning through the consistent and recurring association with primary reinforcers and are referred to as *secondary reinforcers* [10]. *Cues* used by trainers to invite a behavior are typically arbitrary signals (e.g. the word "*sit*") associated with a behavior (e.g. sitting), in turn associated with a secondary reinforcer (e.g. clicker sound), in turn associated with a primary reinforcer (e.g. treats). The less direct the connection between a signal and a primary reinforcer, the lower its biological salience and reliability, the more complex the meaning exchange and negotiation process between trainee and trainer. To manage this complexity and motivate trainees through different learning stages (*acquisition, generalization, fluency* [10]), trainers use a range of protocols (e.g. *molding, luring, shaping* [10]), gradually introducing complicating factors (e.g. increasing the temporal distance between performed behavior and marker delivery or the spatial distance between trainer and trainee; diversifying the circumstances in which a behavior is requested; chaining simple behaviors into more complex series [10]). Given such complexities and how they are managed by trainers, how might the participation of canine trainees express itself? To illustrate this, we report on a simple training exercise with one dog. Our aim is not to illustrate how training should be conducted, but to consider how a dog and a human engage with the training process and what this might suggest about participation in multispecies interaction design.

CASE STUDY

Context

The training activity was part of a research project aiming to develop canine-centered controls that can be retrofitted in domestic or public buildings to facilitate the work of mobility assistance dogs trained to operate a range of domestic appliances on behalf of their assisted humans [21]. These dogs are effectively an interface between the humans and their environment, so it is essential that they can properly access the environment in which they operate. To ensure that the canine controls under development duly account for canine requirements, the project involves the collaboration of canine behavior experts and professional trainers, as well as interaction design and ACI researchers. Until the time of the sessions reported here, our prototypes had only been evaluated with highly trained mobility assistance dogs and their trainers. These dogs are especially selected for their willingness, focus and stamina, and undertake months of training from a young age, which further enhances their capabilities and resilience [36]. At the same time, those who train the dogs are highly skilled professionals, who master the training techniques they use, so the process unfolds smoothly. Here we examine the interaction dynamics between a dog less experienced in complying with training procedures and human researchers less experienced in applying training techniques, expecting this to make such dynamics more explicit. Our aim is to consider what these dynamics might tell us about interspecies participation during training and interaction design practices.

Part-takers

Zena is an 8-year-old female Husky-Labrador Retriever cross, adopted by her human companion from an animal shelter when she was 6. She is a seemingly confident dog, well socialized with humans, cats and other dogs. She is alert and energetic in active situations, while generally asleep when inactive. She has 2 hours of outdoor exercise daily. Off-lead, her recall is generally consistent, but she is easily side-tracked by other dogs' social cues (e.g. gazing, approaching). She is highly motivated by food, but social interaction often proves a stronger motivator. Together with her human, Zena attended level 1, 2 and 3 training classes, where food was used as positive reinforcer.

Clara is Zena's human companion, sole legal guardian and first-time dog caretaker, with awareness of canine behavior and evolutionary aspects of animal behavior more broadly. She is not a canine behavior expert or training professional, but multispecies interactions is a professional interests of hers. During the sessions, she acted as Zena's trainer.

Jussi is an experienced dog guardian and caretaker. He too has a professional interest in human-animal interactions among others. He met Zena shortly before the sessions and contributed to them by filming or taking an active role in the training.

Settings

The activity took place in a building of The Open University campus in the UK. The prototypes were mounted on a display located at one side of the building's very large atrium, which was well lit, well ventilated and relatively quiet, with very few people occasionally passing through. The apparatus, described in detail by Mancini *et al.* [21], included 4 controls (Fig. 1). Two larger controls (one blue and one yellow, 130mm^2 with 20mm protrusion) were mounted next to each other at around 100cm from the ground; when activated, each control switched on a light just above it. Two smaller controls (one yellow and one blue, 80mm^2 with 20mm protrusion) were mounted one above the other respectively at 60cm and 30cm from the ground next to a small automated door; when activated, they opened the door, which closed again automatically shortly afterwards. All the controls could be activated by touch anywhere on their surface and were sensitive enough for even a small dog to be able to activate them with their snout (where dogs have better motor control) as well as with their paw. However, due to their high position (comparable to that of light switches in ordinary homes) even large dogs could only reach the light-switching controls by jumping up and balancing on their hind legs, which would hinder snout interaction; for those controls paw-interaction was the only possibility, hence the larger size to make them easier target. The smaller door-opening controls were at a suitable height for snout-interaction; in particular, the higher one could accommodate larger-sized dogs while the lower one was best suited for smaller-sized dogs.

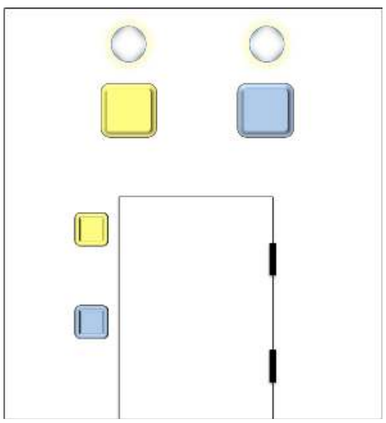

Figure 1. Drawing of the display with the different controls and the small automatic door at the center. The larger yellow and blue controls at the top operate lights just above them. The smaller yellow and blue controls operate the small automatic door at the center of the display.

At the time of the activity, Zena had already spent significant amounts of time at the location and was thus well familiar with the physical and social environment there. She was also very familiar with the campus' grounds and the surrounding fields, where she had exercised multiple times. She had often been in the vicinity of the display but had never seen the controls in use and had never interacted with them and was therefore unfamiliar with them.

Procedure

The sessions were conducted over four days. Each training day, upon arrival at the location, Clara prepared a resting area for Zena, including a soft blanket, a bowl with fresh water and a couple of soft toys, arranged a few feet away from the display. Zena had free access to her resting area throughout the training. Only positive reinforcement was used, in the form of food treats. The training days started late in the morning and ended early in the afternoon. Each training day included several short working sessions lasting approximately one to five minutes each, with numerous breaks lasting approximately five to ninety minutes each. Depending on the duration of the breaks, these involved either lounging around the area, resting on the blanket, interacting with other people, or going out for walks. Each session included between one and seven interactions with the controls. The schedule's variability was determined by Zena's responses to Clara, who acted as her trainer. Sessions started with Clara's invitation to approach the display and were paused or ended when Zena showed any signs of disengagement, such as: light panting; looking away; sniffing the ground; sitting down; lying down; walking over to the resting area and lying on the blanket; moving towards and engaging with passers-by; walking away from the display and towards the entrance of the building. Sometimes sessions were also paused for practical reasons, such as the need to get more treats ready or the arrival of a passer-by.

The training procedure somewhat departed from professional protocols. For example, professional trainers often recommend presenting dogs with new objects, allowing them to spontaneously explore and interact with them, rewarding as this happens. In our case, the objects in question were not conspicuous and Zena had never shown interest in them, so we did not expect her to spontaneously explore them. Thus, we decided to use treats to attract Z towards the controls. During the sessions, Clara always approached the display diagonally from the side of the door hinges (Fig. 1), thus allowing Z to approach from the front or from the side of the door-opening controls, so she could move away from the opening door. When working with the light-switching controls, Clara continued to approach the display in the same way for continuity. When approaching the display, she moved her right hand towards the controls using the word "*touch*" and pointing as cues.

Ethical considerations

The whole activity complied with Mancini's ethics protocol for ACI research [20], which recommends animal protection standards exceeding current legal requirements. The training exercise was comparable to other forms of training Zena regularly experiences and took place in a habitual setting alongside her guardian and with an apparatus pre-tested by humans. Zena was free to move around, and to choose whether to engage or walk away, and thus set the pace of the exercise. She freely engaged with both researchers. Throughout the period, Zena consumed her usual diet and was given her usual exercise, thus the treats used in the sessions and the stimulation provided by the training activities were extras. Overall, the study posed negligent risks to Zena's welfare, while having the potential to provide insights into interspecies participatory design as well as the design of devices enabling dogs like her to better control their living and working environment.

Data collection and analysis

All of the sessions during the training period were filmed and the videos later analyzed with particular attention to the interaction between Zena, Clara, Jussi, and the controls. In total 100.02 minutes of video were recorded over the 4 days. We report Clara and Jussi's intentions in making training protocol choices and in conducting the sessions; and rely on qualitative observation to understand the interaction between Zena and Clara, and between them and the interactive apparatus. We analyze Zena's behavior against Handelman's canine *ethogram* [10]; an ethogram is a description of a specie's behavioral repertoire, which can be used to guide the interpretation of an animal's states.

Sample observations

To illustrate salient moments in the progression of the training, below we focus on selected video extracts.

Day 1

The first training session focuses on the yellow door-opening control (Fig. 1). At this stage, Zena is on a lose lead.

Clara: "*I wanted Zena to associate the cue "touch" with the touching of the control; and the 'click' of the control when activated with the opening of the door and the delivery of a treat.*"

From the video: *Clara approaches the display; she holds a treat with the fingers of her right hand and points to the control uttering the invitation 'touch'. Zena paws at Clara's chest, reaching for the hand that holds the treat and for the treat pouch tied at her waist; Clara puts her hands behind her back until Zena backs down; Clara then puts the treat in front of the control and Zena accidentally touches the control as she reaches for the treat, the door opens and Zena jumps back as if startled. Clara points to the switch again and Zena responds by sitting and going down, then sitting again and gazing at length at Clara's hand, panting lightly. Clara pauses and talks to Jussi; Zena moves away from the display and lies down looking around, lightly panting.* ***Pause***.

Throughout the episode, Zena's body language remains that of a confident, focused dog (ears up and forward, body stance also up and forward, tail up), except when she is surprised by the opening door; she seemingly wants the food (gazing towards it intently and at length, jumping up and reaching for it) but does not seem to know what she needs to do to obtain it and offers behaviors that usually earn her food rewards (these might also be displaced behaviors, i.e. out of context behaviors that express inner conflict), showing sign of mild frustration (slight panting).

Clara: "*I wanted to give her something to move past this impasse, so I decided to ask her for the behaviors she was offering, so I could reward her for these.*"

From the video: *Moving away from the display, Clara asks Zena 'sits' and 'downs', and rewards her; Zena stops panting and looks at Clara more persistently. Holding a treat in her right hand, Clara points to the control. Going for the treat, Zena pushes the control and the door opens; this time she does not jump back. Clara marks and rewards, then leads Zena to her water bowl. Zena lies down for a short while, then she gets up and walks away.* ***Break.***

Zena's body language remains confident; but lying down is likely a displaced behavior indicating disengagement, which becomes obvious when she gets up and walks away.

Jussi: "*I suggested placing the reward on top of the control, so by going for the treat Zena would automatically trigger the control, and also rewarding through the door, so the task would become more interesting for her.*"

Automatically triggering the control when going for the reward makes the touch-reward association more consistent and reliable, and finding a reward behind the door suddenly makes the opening of the door a salient event, all of which is highly reinforcing. Additionally, placing the treat on top of the control frees Clara's fingers and enables her to point to the target, thus cueing Zena [39].

From the video: *Clara places a treat on top of the control and invites Zena to 'touch'. Zena goes for the treat, activating the control which opens the door, as Clara marks. Zena sticks her head through the door looking for Jussi's hand and the additional treat. Again, Clara places a treat on top of the control and invites Zena to 'touch'. Zena goes for the treat and watches intently as the door opens. Waiting for the door to close again, Clara asks Zena for a 'sit'; Zena sits, Clara marks and rewards. Zena walks away.* ***Break.***

Zena is now more willing to engage; her body language suggests a more focused and decisive demeanor (no more displaced behaviors; quick to respond when invited to interact with the controls; forward body posture, tail up, ears up and forward, head through the door when this opens; glance focused on the control and then through the door) (Fig. 2-3).

Clara: "*I thought now I could stop placing the treat on top of the control and instead just point to it.*"

From the video: *Clara points to the control inviting Zena to 'touch'; Zena touches and the door opens; Clara marks and Jussi rewards through the opening door; then Clara rewards too. More successful interactions follow. Then a passer-by comes along and Zena goes to greet them. Clara invites Zena back to the display but she returns to the passer-by.* ***Break.***

Figure 2-3. Zena reaches for the treat on top of the yellow door-opening control, activating it; Zena looks for Jussi's hand to receive a reward through the opening door.

Zena is now performing consistently and her body language continues to portray a confident and engaged demeanor; her tail wags widely and softly signaling a positive, affiliative state. Nevertheless, when she spots them, she chooses to disengage and investigate the newcomer instead.

Day 2

Zena is now off lead. The work still focuses on the yellow door-opening control. Clara is no longer placing treats on top of the control and Jussi is no longer rewarding through the opening door. Zena is operating the control consistently.

Jussi: "*Given her progress, I thought this would be a good time to try with the lower control* [blue] (Fig. 1)*, to see how willing she would be and how easy that might be for her.*"

From the video: *Clara places a treat on top of the control and invites Zena to 'touch'. Zena knocks the treat over without activating the control. Clara places another treat on top of the control and again invites Zena to 'touch'; Zena lowers her head and hits the control plate with the side of her muzzle; Clara marks and rewards. Zena looks towards the building's entrance and then around the place.* ***Break.***

The low position of the blue control forces Zena to lower and turn her head sideway (Fig. 4), which in canine-to-canine interaction can be a distance-increasing behavior associated with submission or uncertainty, and is seldom presented by Zena. It is not surprising that, immediately after activating the control, Zena disengages by exhibiting what could be displaced behavior, that is looking towards the exit and around. Even after a break, things don't seem to improve.

From the video: *When Clara invites her to 'touch' the control, Zena sits down gazing at her instead. Clara again cues her, but Zena goes down. Clara leads her away from the display and asks her for 'sits' and 'downs', marking and rewarding. Then Clara cues Zena again and she touches. Again, Clara leads her away from the display and asks her for 'sits' and 'downs', marking and rewarding, before cuing her again to 'touch' the blue control, but Zena paws at Clara's hand instead. Clara then cues Zena to 'touch' the yellow (door) control, which she does with no hesitation. Clara stops to talk to Jussi and Zena walks away.* ***Break.***

Figure 4. Zena is about to touch the blue door-opening control, lowering and side-turning her head as she approaches.

Zena seems unwilling to engage with the lower control, offering alternative behaviors instead. To encourage her, Clara alternates invitations to engage with the control and requests for familiar behaviors, but this does not persuade Zena, who is however ready to engage again with the higher control. Her body language remains confident throughout and she is 'forward' enough to paw at Clara's hand, but this may suggest displacement and possibly frustration.

Day 3

Zena and Clara continue to work on the yellow door-opening control. Zena engages consistently and moves towards and away from the display spontaneously. So, Clara begins to point to the control from a small distance, and when the distance is within 20 centimeters Zena engages consistently.

Clara: "*At this point I thought we could try working on the yellow light-switching control* (Fig. 1)."

From the video: *Clara places a treat on top of the control and invites Zena to 'touch'; Zena jumps-up and touches the control with her paw, going for, but not reaching, the treat* (Fig. 5)*; Clara marks and rewards. Two more times, Clara places a treat on top of the control and cues Zena; both times Zena jumps-up and touches the control, Clara marks and rewards. The third time, Zena sits down looking at Clara, then at the control, then back at Clara. Clara tries again and Zena reaches for the treat, Clara marks and rewards. Then Zena walks off cutting the session short.* ***Break.***

Figure 5. Zena jumps-up to reach the treat sitting on top of the yellow light-switching control.

Zena's demeanor shows hesitance and her alternating gaze between the control and Clara is a way of inviting her intercession to obtain the hard-to-reach treat [42]. Zena breaks the session early by wondering off and sniffing the ground, likely a displaced behavior, and soon stops responding to Clara's invitations altogether, lying down distant from the display and facing the opposite direction, indicating complete disengagement, which ends Clara's attempts to work with the light-switching control.

Day 4

Zena continues to engage reliably with the yellow door-opening control, even when Clara points to it form a small distance (Fig. 6-7), showing a confident demeanor throughout. She operates the control, with no need for treats to be placed on top of them or delivered through the door. If occasionally she does not trigger the control when cued, Clara ends the session. Zena is now proficient with this control, while training on the other two has ended. Nevertheless, at some point, she spontaneously approaches the display and touches the lower door-opening control, this time, using her front paw rather than her snout.

Figure 6-7. Clara asks Zena to touch the yellow door-opening control, pointing to it from a small distance; Zena touches.

DISCUSSION

A co-constructed outcome

The training sessions presented above illustrate how, at the beginning of the training period, the interaction between Clara and Zena shows misalignment (for want of a better term). As transpires from her demeanor and body language, Zena's goal seems to be getting the treats, while Clara's goal is to show Zena what to do with the controls. However, Zena ignores the door-opening control, towards which Clara is trying to direct her attention; on the other hand, Clara is uninterested in emptying the contents of the pouch, which Zena is attempting to reach for. Upon seeing the treats, Zena spontaneously offers behaviors (sit, down, etc.) that would normally earn her the reward, something she has previously learnt. As she reads signs of frustration in Zena's behavior, Clara responds by asking her to perform one of the behaviors she has been offering, which allows Clara to reward her with the treats she wants. This results in Zena becoming more willing to engage with Clara's cues. In other words, Zena gets some treats, but on Clara's terms, while Clara gets Zena's attention but on Zena's terms. As the clicking of the door-opening controls and the opening of the door gradually become associated with the acquisition of treats, Zena begins to engage and things begin to progress, with Clara and Zena negotiating a way forward.

Although she has to play Clara's game, during the process, Zena is able to set the pace, 'price' and even form of her involvement. She chooses when to engage, going along with Clara's invitations to interact with the controls. She also chooses when to disengage, exhibiting displaced behaviors, going to her blanket, walking out of the building or moving towards and greeting passers-by. Zena also decides whether the reward on offer is worth the effort required by the task, disengaging from a control that is hard to reach, while continuing to engage with an easy-to-reach control. At some point, she even takes the initiative, by spontaneously approaching and touching the lower door-opening control, thus inviting Clara to respond, and by using her paw as an alternative way of interacting with it, which does not require her to assume an undesirable posture; this is in spite of the bias towards snout interaction that Clara has created by placing treats on top of the controls. On her part, Clara and Jussi have to play Zena's game and try to keep her motivated. They incorporate familiar tasks, such as 'sit', in the procedure; and try to make the opening of the door salient for Zena by rewarding her through it. When Clara asks Zena to touch the higher light-switching control, which require greater effort, Zena demonstrates her reluctance to work and eventually disengages altogether. In these cases, Clara could have increased the value of the reward, by offering a more desirable treat, but maintaining the reward relatively constant made Zena's preference for one of the controls clearer.

In the end, Zena is willing and able to reliably engage with the higher door-opening control but is mostly unwilling or unable to engage with the other controls. This is consistent with findings from studies with other dogs within the same project [21], according to which the excessive height of controls can be problematic, requiring the dogs to perform ergonomically inappropriate actions, such as jumping-up and balancing on their hind legs. Here, we also suggest that, not only physically non-accessible interfaces (such as controls that are out of reach), but also interfaces requiring the dogs to assume postures normally associated with less than positive emotional states (such as controls that are too low for snout interaction) can be problematic. In the end, Zena's (and other dogs') feedback during the project has informed the next generation of wireless controls, which afford better accessibility and acceptability with regards to snout interaction, where dogs have greater motor control, while allowing them to maintain a confident posture whatever their size.

Training as a participatory practice

At the end of the sessions, Clara has learnt something about the accessibility and acceptability of different prototypes to inform future designs, while Zena has shown preference for the control whose operation requires the least physical effort and enables her to maintain a posture that is consistent with her spontaneous demeanor and positive emotional states. This outcome is the result of each party engaging in pursuit of something they wanted. As we discussed, animals (including humans) demonstrate *wants* [40] that are underpinned by fundamental evolutionary drives, whose function is to keep the animal alive and enable them to reproduce [1]. These drives are activated by contextual stimuli that motivate individuals to behave in order to fulfil them. Through experience, animals learn to respond to stimuli to readily fulfill their drives and in turn learn to want things that enable them to pursue what they want. Whether the result of evolutionary or environmental conditioning, this is an active pursuit and it is animals' capacity for *volitional engagement* that makes operant conditioning possible. To engage Zena's volition, Clara and Jussi endeavor to motivate at least one of her fundamental drives (self-preservation), by using food rewards as operant stimuli. Along the same lines, Clara and Jussi endeavor to enhance the biological salience of the training task, whereby the opening of the door gives access to the food rewards. This results in Zena's greater willingness to work and it expedites the training process.

Of course, in order to fulfill their wants animals need to be able to make sense of the world around them. Mancini *et al.* [23] discuss the role of indexical semiosis in technology mediated human-animal interactions, whereby (human and other) animals are capable of establishing contextual associations between consistently co-occurring events. For example, for dogs who consistently wear a tracking collar when walking off lead, being fitted with the collar becomes a reliable indicator of an exciting time ahead, much in the same way as a marker becomes associated with a reward during formal training [23]. Likewise, the reliable co-occurrence of events during the training sessions, such as when treats are placed directly on top of the control and Zena thus triggers this as she reaches for the treat, leverages and supports her associative capacity. This capacity underpins all biosemiosis, enabling even the simplest organisms to attribute meaning to events, and thus make (their own) sense of the world (at whatever level of abstraction and complexity). It is this capacity for *semiotic engagement* that makes both classical and operant conditioning possible.

In other words, training is a semiotic, volitional process bringing together different agents (each bringing to the table the semiotic, volitional processes that made them who they are). But without choice volition has no expression and semiosis has no use, thus enabling *choice-full* engagement is key. Within the training context, semiosis and volition are enabled and expressed through the choices made by both agents during their interaction. In animal welfare research, scientists have devised tests to measure the strength of animals' preferences in relation to environmental stimuli and resources [41]. Similarly, preference tests have been used to garner animals' input when evaluating or eliciting requirements for wearable [18] or tangible [35] interfaces designed for them. In this regard, Ritvo and Allison pointed out [33] the importance of giving animals choice, by providing them with options for non-interaction as well as interaction options.

Of course, in any situation choices are always limited and never entirely free: there are only so many design variations that can be offered at any one time; and each agent is already conditioned by the semiotic, volitional processes, which have made them who they are and which they bring to the table. But, provided a space where each agent can make choices, there is room for volitional engagement, for semiotic engagement and for negotiating an outcome that can inform the design process. In this respect, the fact that Zena engages with different prototypes in different ways or to different degrees provides insights into the accessibility and acceptability of the current designs. These aspects can then be further explored, and prototypes tested and refined, for example, by offering alternative variations and by increasing or decreasing the quantity or value of rewards to see how Zena responds.

In other words, as a relational, reciprocal practice directed by each party's semiotic, volitional and choice-full engagement, training is essentially participatory. As such, it enables agents, who do not speak the same symbolic language and whose power relationships are seemingly asymmetric, to enact a conversation through which specific interaction design problems can be explored. Well beyond interaction design settings, reciprocal training is the mode of organisms' coexistence and coexistence is ongoing reciprocal training [12]. By the same token, participation is too, necessarily, a form of reciprocal training.

Participation in interspecies interaction design

During their enacted conversation, Zena and Clara both interpret each other's signals and respond to the other, based on the meaning they attribute to those signals, in a back and forth exchange. Despret [5] describes this exchange as a constant movement of *attunement*, which enables negotiated meanings to emerge and responses to converge, and which thus enables (human and nonhuman) animals to work and accomplish things together. Progressing from the initial misalignment, gradually Zena and Clara's interactions become more aligned, so that both parties achieve something they want, but not without doing what the other wants. As Despret puts it [5], this process of alignment is possible because, for diverse reasons, the desires of the two parties overlap, and because each party subordinates their desires to what makes sense for the other. In other words, making (associations, meanings, designs, worlds and, ultimately, one another) is the result of a dialogic negotiation.

Thus, making can only be *making with*, to say it with Haraway [11], who stresses that 'making with' is always a situated process, in which specific individuals, specific set-ups and specific contexts do *matter*. In other words, whether interaction design practices enable multispecies participation depends on the characteristics of the specific (training) spaces that designers set-up and of the (training) procedures that these spaces support; it depends on how these practices enable partakers to respond within specific interaction design processes and whether they afford opportunities, not only to comply, but also to divert from and subvert the course of the interaction. When Zena spontaneously hits the lower door-opening control with her front paw, even though all along she had been encouraged to use her snout, not only does she demonstrate a grasp of the tasks; she shows a different, better way of interacting with that particular control.

Of course, 'making with' is a *messy* [11], uncertain, open-ended process, in which opportunities can only be discovered by embracing its limitations. Indeed, the interaction design process is arguably highly adapted to dealing with such limitations, accounted for by the iterative nature of its cycles, whose function is precisely to unravel the layers of complexity characterizing interaction design problems. In this respect, interaction design can be seen as a process of incremental orientation towards an optimal final outcome that may never be reached, but that can be approximated. Thus, attending to the process by carefully crafting spaces and procedures that foster the emergence of participatory engagement is arguably more important than any interim design outcome. In this respect, the question is not whether Zena 'really' has a desire to operate those controls; the question is whether the specific set-ups and procedures in place, and the interactions these afford, allow her to make (her own) sense, express (a measure of) volition and exercise (some kind of) choice, thus enabling her to respond (through compliance, diversion or subversion) and inform (both providing information for and shaping) the design process.

We suggest that (multispecies) participatory spaces could be defined along the following dimensions, the specifics of which *matter* when crafting such spaces:

- *Biological salience* matters in relation to volition. This concerns participants' interactions with set-ups and other participants, and reinforcers associated with both. For example, input controls that force an animal to spend excessive energy or assume fearful postures contravene a social drive; while system outputs associated with the acquisition of resources satisfy a self-preservation drive. Interacting with trainers associated with reinforcing experiences also satisfies a social and self-preservation drive. Reinforcers that satisfy fundamental drives are likely to motivate engagement, as they are inherently meaningful, although preferences may vary between individuals (e.g. food vs objects that mimic prey). For animals with greater capabilities of abstraction, stimuli that have a symbolic connection to fundamental drives can also be motivating (e.g. money for humans vs food for dogs).
- *Signal reliability* matters in relation to semiosis. This concerns the extent to which participants can trust, and thus respond to, the signs they perceive and attempt to interpret during an interaction. The more a signal behaves like an index, the more it can be relied upon. Consistent co-occurrence and space-temporal proximity facilitate associations, for example, between a system input device and its output; between a behavior and the reward that follows. Here too, for animals with greater capabilities of abstractions co-occurrence can be deferred and displaced, or symbolically expressed.
- *Engagement options* matter in relation to choice. This concerns the opportunities a participant is afforded to express preferences that can orient the design process. It may include the provision of different interface designs for an animal to engage with (e.g. alternative input controls for the same output; alternative outputs for the same input control); or the possibilities for engagement afforded by an interface (e.g. snout vs paw operation); or the opportunities afforded for engaging with or disengaging from the process at any given time (e.g. going along or walking away).
- *Contingencies variations* matter in relation to volition, semiosis and choice. This concerns the way in which variations in motivators, signs and options may help assess the extent to which a participant can and wants to engage. For example, varying the value of rewards when an animal engages with a given interface may indicate the level of difficulty or motivation they experience; maintaining the reward value constant when an animal engages with different interfaces may indicate their preferences. Environmental variations (e.g. distractors) also matter and may affect an animal's level of engagement.

Beyond the example with one dog discussed here, these dimensions are more broadly relevant to animals (including humans) with diverse sensory, cognitive and physical characteristics, who possess volitional, semiotics and choice-full capacities. Arguably, the framing proposed here has the potential to support the development of the kind of non-speciesist practices advocated within ACI [20,24].

CONCLUSION

Interactive technology has become ubiquitous and now informs almost every aspect of human activity, including the many activities that also involve other animals, so that they too have become *interactors* [29]. Thus, the thinking around diversity in interaction design needs to move beyond anthropomorphic notions of participation, which assume that part-taking agents should have shared understandings of, and shared goals for, design activities [28]. Such notions assume, and measure, participation in relation to capabilities that only (some) humans possess, in turn leading to anthropocentric discourses and practices. Inevitably, these discourses and practices tend to exclude, devalue, dismiss, delegitimize, or render invisible the participatory contribution of agents who do not possess the capabilities to enter symbolic, deferred, abstract conversations, away from the specificities of the 'here and now' [20].

Here, we have pondered the elements of participation within multispecies interaction design to illustrate its emergence, in spite of interspecies asymmetries and even within the constraints of training procedures. Aiming to move towards the development of broader models of participation, we have suggested dimensions that matter when considering more inclusive participatory practices, resilient to the diversity of understandings and goals among part-takers. We suggest that these could help designers craft spaces in which participation can emerge through part-takers' semiotic, volitional and choice-full engagement, thus leading to incrementally co-constructed outcomes; and practices which appropriately account for the contribution of diverse agencies to the design process, so that technologized multispecies ecosystems can represent all those who live in and sustain them.

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