Horse as Teacher: How human-horse interaction informs human-robot interaction

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Figure 1: Students and instructor at the Horse Teaching Unit gather at the end of the Fall and Spring semester classes.

ABSTRACT

Robots are entering our lives and workplaces as companions and teammates. Though much research has been done on how to interact with robots, teach robots and improve task performance, an open frontier for HCI/HRI research is how to establish a working relationship with a robot in the first place. Studies that explore the early stages of human-robot interaction are an emerging area of research. Simultaneously, there is resurging interest in how human-animal interaction could inform human-robot interaction. We present a first examination of early stage human-horse interaction through the lens of human-robot interaction, thus connecting these two areas. Following Strauss' approach, we conduct a thematic analysis of data from three sources gathered over a year of field work: observations, interviews and journal entries. We contribute design guidelines based on our analyses and findings.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; • **Computer systems organization** → **Robotics**.

KEYWORDS

Human Animal Interaction, Qualitative Methods, Human Robot Interaction, Design Guidelines

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1 INTRODUCTION

Robots are entering our lives and workplaces as companions and teammates. For example, social robots have been explored in the context of therapy, education and entertainment for children [46, 60, 62] and in the context of mental and physical support to older adults [11, 20, 39]. Factory robots are increasingly expected to work collaboratively with human workers and in this context are sometimes termed co-bots, to emphasize their capacity as a co-worker or teammate [3, 43, 56]. However, humans and robots do not start out already 'knowing' each other. While introduction and familiarization is a necessary part of studies involving first-time users such as children or older adults or the lay public, there are no fundamental guiding principles in the human-robot interaction (HRI) literature for how to go about building an effective working relationship. Only recently have researchers started focusing on the earliest stages of human-robot interaction, such as the creation of first impressions [50] and the process of opening the box [36]. Our work seeks to uncover principles for the stage after the first meeting.

We hypothesized that these fundamental guiding principles might be discovered by looking at a parallel that has existed for millennia but has not yet been leveraged to provide insights for HRI: human-horse interaction. Horses were first domesticated five to ten thousand years ago [18]. Subsequently, human-horse partnership transformed how food was produced, how goods and people were transported, and how wars were fought and won [54]. Today, horses are companion horses kept for pleasure such as for recreational trail riding, teammates in competitive activities such as racing, dressage and showing, and co-workers in fast-moving, high-precision work such as cutting, reining and roping cows on a ranch [32]. Horses sense their environment and their rider, they are responsive to their rider, they learn and are trained. They are, in a manner of speaking, the kind of robotic teammate and companion that is the holy grail for HRI. In this paper, we present a first examination of human-horse interaction through the lens of human-robot interaction. Our work makes the following ***contributions***: (1) Identification of a novel metaphor to guide the field of HCI/HRI, (2) Inductive analysis of of data collected over a year of observations, interviews and journal entries around the early stages of relationship building in human-horse interaction, (3) Design guidelines and example instantiations for HRI research and practice.

Indeed, robots are going to occupy the same role in our society that domesticated animals once did. Human-robot interaction researchers are calling for the community to draw on the rich knowledge base about human-animal interaction to inform theory and practice in human-robot interaction. Darling's book explicates on the ways in which humans and animals have interacted and compares them to robots in similar contexts [15]. Lagerstedt and Thill [35] argue for human-animal interaction as a benchmark for HRI in several contexts. Hancock and colleagues examine human-animal teams to theorize about trust in human-robot teams [8, 52]. This decade's work follows the bio-inspired perspective that had informed Arkin's seminal work on defining behaviors [4], Blumberg's work on replicating training methods [9] and Friedman's work on comparing people's interactions and relationships to Sony AIBO robots with real dogs [22, 42].

Much of this literature, with a few exceptions, has centered on canines. Canines are convenient to study and can serve as a benchmark and a target in contexts such as search and rescue or assistive robotics. In contrast, our work is the first to examine the robot-animal parallel for equines. Equines are larger and heavier than canines. Importantly, they are also larger and heavier than humans. Like canines, they are found all over the world (in contrast to llamas, camels, elephants and similar animals that partner with humans in the transportation and farm work contexts). Unlike canines, they are ridden and are in that sense used as exoskeletons. Equines are prey animals, and this position in the food chain means that they have evolved to favor nonverbal communication such as nostril flaring over verbal communication such as barking. Training is accomplished through release of pressure rather than food rewards, which means that the human uses their body quite differently in human-equine interaction compared human-canine interaction. These differences between equines and canines yield novel insights that are quite distinct from previous work with canines.

2 RELATED WORK

Animals have inspired social robots' form and behavior Roboticists have long looked toward animals for behavioral prototypes that are familiar to humans and are effective for communication between human and non-human. There are numerous commercially viable zoomorphic social robots, for example, the Joy for All companion pets for older adults include robotic birds, cats and dogs [1], and the PARO therapy robot mimics a baby seal [2]. The vast majority of this body of work has considered dogs as inspiration, with Sony's AIBO as the exemplar [4, 31, 41, 42, 59, 60]. For a systematic description of studies in the context of therapy and social companionship, see Krueger and colleagues' recent survey of literature that uses dogs as prototypes [34].

Inter-species interaction contains lessons for HRI Kate Darling's recent book on this topic extensively catalogues the ways in which humans and animals have interacted and parallels with human-robot interaction [15]. She is part of a growing number of voices that call for an ethorobotic approach, in which HRI looks toward existing interspecies interactions to develop interaction templates and evaluation methodologies [8, 23, 33–35, 44, 52]. Miklosi, from whose writings this term originates, argues that dogs do not have all of our social skills and yet they have successfully become part of human social groups; as a result, social robots do not need to replicate human social skills, rather, they need to have social competence, i.e., the ability to interact effectively with humans and other robots (heterospecifics and conspecifics). Our study aligns with this overall approach: we examine the early stages of relationship building between humans and animals as a source of inspiration for similar interactions between humans and robots. While this approach encourages the study of animals in general, the specific animal that has been studied thus far is the dog. Our study adds a new axis of inquiry to this body of research by proposing human-equine interaction as a rich source of insights that will complement insights derived from human-canine interaction.

Human-equine interaction Much research on human-horse interaction has been undertaken by veterinarians and animal scientists for the purposes of improving well-being and performance [27, 37, 40, 48]. For example, Hall and colleagues surveyed the knowledge base on behavioral and physiological signs of discomfort and pain in horses [27]. They concluded that there was a need to improve objectivity in assessing horse discomfort. Indeed, technology for animal welfare is an active area of research, and Lesimple's recent review of the literature collates various indicators of horse welfare to identify signatures of pain, discomfort and stress [37]. Horse-computer interaction, such as when smart stables use computer vision based sensors to monitor behavior [48], is distinct from our work in that it considers the horse as a user, albeit an unaware interactor or lower-in-power user. In contrast, our work considers the horse as teacher, and investigates how a horse interacts with humans with a view to learning from the horse.

Animal sciences literature on horse-human interaction contains rich descriptive accounts of horse behavior in different contexts. McGreevy and colleagues, for example, described horse behaviors when interacting with humans during training and handling, and compared these behaviors to those observed when horses interacted with other horses [40]. Their tabulation illustrates those behaviors in horse-human interaction that have analogues in horse-horse interaction. In this sense, their goal is the same as ours: what can we learn from a horse's interactions in a setting where it has been a successful member of a team and apply it to another context? The specific outcome of ethological research, i.e., detailed descriptions of animal behavior, could be useful for HRI in and of itself because the descriptions could provide inspiration to designers for ideas around non-verbal behavior primitives for robots. However, these descriptions do not help HRI researchers think about how the horse-human relationship develops.

The horse-human relationship has been examined by animal scientists from the perspective of accident prevention [28]. The premise here is that there are natural occupational hazards to working with a horse, for example, being bitten or kicked. Thus, there is a need to develop a better relationship between the human and the horse, which refers to interactions with fewer accidents. The human-horse relationship has also been considered from the sociological and anthropological perspectives, in terms of how it has changed human societies at the macro scale [18, 54] and the development of individual and collective identity at the more micro scale [16]. This literature will no doubt be of future interest to the HCI/HRI research community as sociological questions such as development of identity and the nature of the relationship between humans and social robots are areas of interest for the community...once we make the leap that we have much to learn from the horse. This is in fact the major novel contribution of our work: putting human-horse interaction as a rich source of insights and guidelines on the radar of HCI/HRI researchers.

Interaction, relationship and attachment Our insights are in the realm of early-stage relationship building. The HRI community has extensively explored concepts such as interaction, relationship and attachment, along with related notions such as trust. Following Lagerstedt and Thill [35], we consider interactions to be individual, short contacts that accomplish a goal and relationship as a later stage where the interacting agents have developed "a shared history". Bonding or attachment refers to persistent connection that results from interactions and relationships over the long term. The notions of interaction and attachment with canine-inspired robots have been extensively investigated [34], as have similar notions for PARO, the baby seal-inspired therapy robot for older adults [29]. In our study, we consider interactions to refer to verbal and non-verbal primitives used for communication, for example, a human might interact with a horse through their hands, legs, and/or seat.

Trust Trust is becoming an increasingly active area of research in human-AI interaction in general [6] and in human-robot interaction in particular [65]. Trust has been measured in contexts as diverse as domestic [5], healthcare [57], and warehouse work [21]. Recent discussions on trust have also noted how difficult it is to precisely measure trust [12] and replicate study outcomes on a different robot [63]. In the teamwork context, if a human does not trust their robotic teammate, it will impact the degree to which they will accept its sensor data or suggestions for a course of action. We note that trust and attachment can exist independently, for example, my neighbor is attached to his dog but does not trust him to be alone with my child. Trust and interaction are also distinct concepts, for example, my horse teacher trusts the horse she has ridden for two decades more than her son's new horse; but because they are both trained horses, she expects to interact with them in the same way, i.e., using the reins and legs to give signals to move and stop. The way trust relates to the concept of relationship is that it is a key ingredient in any relationship: we cannot work with someone effectively if we do not trust them. Hancock and colleagues [8, 52] have looked toward trust in human-animal teams to inform trust in human-robot teams. They describe how humans learn to trust animals (the human must be able to predict the behavior of the animal in different circumstances, for example) and how trust can change over the course of interactions. They distinguish between animals as companions in a low-intensity environment (pet-type interactions) and animals as co-workers in a high-risk environment (riding a horse or operating a dog sled). They argue that trust involved in risky activities is more than that in pet-type interactions. Interestingly, they have highlighted two precursors to trust: "...mutual trust can only occur after an established means of communication and respect between the two entities have developed..." [8]. Both communication and respect emerged in our inductive data analysis. While Hancock and colleagues discuss these themes within the entire landscape of human-animal teaming, we study one animal in depth and report our findings in the context of that animal.

Introductions and first impressions The majority of HCI/HRI studies with robots generally assume that the robot and the human already have a working relationship with each other and the purpose of the interaction is to complete a task. In fact, introductions and first impressions are critical to how a virtual agent or a robot is perceived [7, 10, 50]. Past work reports that gaze and smile impact a user's decision to spend time with an agent [10] and first impressions persist across repeated interactions [50]. It is only recently that HCI researchers have started designing for early stage interactions, specifically, the introduction of a robot and a human. Lee, Cagiltay and Mutlu examined the process of a child taking a social robot out of its box, setting it up, and interacting with it for the first time [36]. Through their design and evaluation study, they recommend for example that the initial experience between a child and a robot be both social and interactive. This introduction process is relevant to users beyond children– it will need to occur for every robot that interacts with a human, whether in a work setting or a social setting. Our work adds to this new frontier in HCI/HRI by distilling lessons from early stage human-animal interaction. For example, our findings with human-horse interaction can inform how to move from the first introduction to the next more complex interaction and then the next: at each stage, horse trainers test a horse for whether it respects the human.

3 METHOD

3.1 Research Sites and Participants

This research study analyzed data collected through three methods: observations, interviews, and journal entries.

Observational study The observational work was conducted at the Horse Teaching Unit (HTU) at the University of Florida. The HTU is one of two teaching facilities that supports the equine studies course work in a top-5 program in Plant and Animal Sciences in the United States. The facility comprises 65-acres of farm, including barns, grounds, stalls, round pens, walkers, and a covered instructional arena with bleacher seating for 300-500 people. The UF Equine Studies program breeds horses at a specialized breeding and foaling facility. Yearlings are trained at the Horse Teaching Unit by students as part of a series of two semester long courses. Trained horses are sold at the annual spring sale and the generated income is used to support the teaching farm activities. The first author gathered observational data (hand-written notes) nearly every week for two semesters (Figure 1). Because of the timing of the study, the first author observed the spring course first, and then fall course. This reversal was fortuitous because it gave the first author some time to learn the terminology and the rhythm of the class. In addition, the instructor, teaching assistants and students became accustomed to the first author's presence, which allowed her to both observe the fall course as well as conduct interviews with students, teaching assistants and the instructor.

Training yearlings is a hands on activity. Every class started in the indoor classroom at HTU or in front of the tack room, depending on the activity of the day. Then students proceeded to the stalls to groom their horses and lead them to either the round pens or the indoor arena. The class ended with horses being brushed, washed and turned out into the fields. As a result of the nature of this work, observation involved following students from the stalls to the arena to the round pens and so on. This setting did not lend itself to audio-video recordings. The first author relied on paper and pencil notes taken in short-hand during the class, and filled out in her car in the parking lot once the class was over.

Interviews The first author conducted semi-structured interviews with the instructor after the class, each lasting 30-45 minutes, roughly once a month (i.e., 3-4 interviews in a semester). The first author also conducted opportunistic interviews with the students and teaching assistants. These interviews included short 3-5 minute clarifications on the activity being observed, 5-10 minute guided conversations with students who were done early for the day, and one impromptu group interview for the class as a whole when the instructor was running a few minutes late. Notes from these interviews were thus interspersed within the observation study notes.

In addition, the first author interviewed several equestrians who were not affiliated with the HTU. These interviews included an expert horse trainer (>30 years of experience) at his horse farm, an amateur dressage trainer, an amateur mustang adopter, and two equestrians who kept horses in their yards for light ranch work and recreational riding. The expert trainer specialized in re-training ('fixing') thoroughbreds and race horses who were having 'people problems': refusing to be saddled, bucking or otherwise not working well with their riders and trainers.

Reflections as participant-observer Over the course of six months, the first author learned to ride horses through weekly lessons. These lessons started at the very basics (parts of a horse, how to approach a horse, how to saddle and bridle, how to lead a horse) and involved ground work, saddle riding in the Western style, and horse care such as brushing, washing, and cleaning out stalls. They were conducted at the horse farm of an equine sciences faculty. The expert trainer was the faculty's spouse. This close connection could have resulted in a high degree of similarity in the author's observations of horse-human interactions at the HTU and the riding lessons. Mitigating factors include the trainer being aware of the author's observational work and commenting on similarities and differences, for example, "You may have seen it done this way for the younger horses but for the older horses this other way is okay because they are used to me doing it". At the end of each lesson, the author recorded descriptive notes as well as her own reflections in her journal. When the author reviewed her notes and found that her observations at the riding lessons and the HTU class did not align, she asked for clarifications from the respective experts.

3.2 Scope and Context

The author observed human-horse interaction in two contexts: the first, observing trainers-in-training in the classes taught at the HTU, and the second, as a participant-observer when the author herself was a rider-in-training. In both contexts, there was an expert present: the course instructor in the first context and the riding instructor in the second context. Because of these two distinct contexts the horses themselves were at two stages of training: in the class, the horses were yearlings and this class was the first time they were being handled by humans with the goal of training them to become ridden horses, whereas in the context of the author's riding lessons, the horses were mature, well-trained animals (18-20 years old) that had extensive showing and ranching/training experience.

Despite these differences, what was comparable in both contexts was that the author was observing the early stages of building the horse-human relationship. In the classes at the HTU, the young horses were being handled consistently by the same trainer for the first time and they were learning to develop a working relationship with that trainer. In the context of the author's lessons, the horses were handled by the author for the first time and were learning to work with an early-stage rider.

3.3 Positionality

The subjective nature of inductive coding compels us to examine the positionality of the researcher and how their experience and outlook may have impacted the coding process.

The first author who conducted the interviews, observational work and was the participant-observer serves on the faculty of the Department of Computer and Information Science and Engineering at a major public university in the area of human-centered computing. She holds a doctorate in Robotics. Over her sabbatical leave, she conceptualized and conducted the activities in this report. She has supervised graduate students on projects related to driver attention, highly automated vehicle design, and generating stylized and expressive motion. In the course of her study, she realized that while horses were an interesting parallel to Level 3-4 autonomous vehicles, the contexts in which they are used in current times is companionship, such as trail riding, therapy, such as equine assisted therapy, and high precision high speed teamwork, such as racing and ranching. Her training and research experience with robotics, attention and expression inform the data analysis. The first author is aware of confirmation bias and strove to alleviate this risk by following best practices of qualitative methodology and consulting with the second author during the inductive analysis.

The second author is an associate professor in the same department as the first author. Her research area is computer science education. She is well versed in qualitative coding methodology. The second author reviewed the first author's coding scheme and thematic analysis and oversaw methodological rigor.

3.4 Data Analysis

The observations, interviews, and participant-observer activities yielded hand-written notes, which were typed up. Data was coded inductively following Strauss' methodology [13]. Primary codes were clustered into categories and then into themes. Codes were iteratively refined through constant comparisons and the categories updated accordingly. During the comparison and refinement process, written analytical notes and diagrams were used to keep track of categories and their relationships. Table 1 illustrates our inductive thematic analysis for one emergent theme. In the detailed description that follows, excerpts from field notes will be refered to as *<datasource>-<date>*, for example, field notes from an interview on *June 23 2021* are annotated as *I-21-06-23*. Names are shortened to first initials to protect the privacy of the participants.

Table 1: Example of inductive content analysis

Data Source	Raw data	Code	Category	Theme
Interview	*How do you get him to go faster? "Sound of whip, smooching, pressing on sides"*	Auditory signal, Physical signal	Directives	How the human communicates with the horse
Interview	*She could make the horse move sideways by tapping her on one side with her reins. She patted (or maybe did a soft push) on the hind section to make it move its hind legs.*	Physical signal		
Observation	*Another student is teaching her horse to respond to verbal commands "trot" and "canter"; trot is accompanied by a clicking sound; canter is accompanied by a kissing sound.*	Signal redundancy	Characteristics	
Journal	*When he was tired…I had to apply leg pressure in addition to saying "jog"*	Signal hierarchy		
Observation	*He asked the student to slow the horse to a walk. The student said "whoa" and was immediately corrected "don't use whoa. You can say easy if you want. But whoa is for a complete stop.*	Avoid mixed signals	Art and skill	
Journal	*If you don't get the timing right, he'll be midstride and he'll need to complete the step before he can turn.*	Timing		
Interview	*... some people talk more to their horse; some would rather use leg others would rather say "walk"...*	Personalization		

4 FINDINGS

Human-horse partnership transformed how wars were fought, people and goods were moved, and food was produced [18]. Today, horses are not widely used for war (perhaps the only exceptions being mounted police and guerrilla warfare) or transportation or tilling fields. Horses are now bred and trained for three major equestrian disciplines: ranching, racing, and showing/dressage. Tables 2, 3, 4 summarize the main findings.

4.1 How the *horse communicates* with the human

There are two aspects to this theme: first, the mechanics of how the horse communicates with the human, and second, the qualitative nature of how the horse communicates with the human. We found both these aspects to be salient in the early stages of human-horse interaction. In terms of mechanics, the horse communicates primarily through non-verbal cues. In terms of the qualitative nature of communication, the horse must be respectful to the human. We provide details on each of these aspects below.

4.1.1 Horse language is body language. In our interviews, observations and domain study, we found that the knowledge base around horse-human interaction starts with the understanding that the horse is a flight animal [67]. In other words, it is a prey animal that has evolved to protect itself by fleeing a predator. The horse communicates in a way that relies primarily on non-verbal signals as sound can give its position away to a predator. Sound is used as an escalation when non-verbal signalling does not work. Non-verbal signalling involves subtle gestures, for example, the horse's ears pointing in the direction of their attention, as well as larger movements. As part of the horse training class, student trainers were conducting a desensitization exercise with the yearlings they were training. Yearlings are young horses between one and two years in age. The goal of this exercise was to train the young horse to ignore stimuli such as waving flags or rustling plastic bags and pay attention only to their human. Horses are naturally alert to stimuli that contain fast movement or noise because those stimuli could be predators. One horse could not ignore the flag his trainer was waving.

O-21-09-10: "One (white) horse was afraid of the orange flag...The student trainer was holding on to his lead rope and waving the flag. The horse thought the flag would hit him and moved his head away. His ears were following the flag. He did not like it at all when the flag touched his body. When the flag was on the ground and came near him, he stepped away from it."

This horse moved its ears to follow the stimulus. The movement serves several purposes: directing sensory and perceptual resources toward the potential threat, communicating the object of the horse's attention, communicating the horse's affective state. Ethographic accounts of feral horses have noted similar postural display of attentiveness [53]. The horse did not use vocalization at this stage to communicate that it perceived a threat.

In addition to environmental threats, a horse's ears also communicate its attentiveness to the human. Across our observational work, we noted trainers remarking on where the horse's ears were pointing, for example, whether the horse saw a deer or whether he was paying attention to the trainer. A student remarked that she knew her horse understood when she says "no" to him because of how his ears move: *I-21-10-29: "I had one that understands no"– What does he do when you say no? "He kind of looks at me and his ears go up like that." [gesture]"*

Riders and trainers learn to look for a range of non-verbal cues, from subtle cues such as the position of the ears and the tension in the muzzle, to larger cues such as raising the neck and foot stamping.

4.1.2 The horse must respect the human. In addition to learning to read the body language of a horse, the early stage rider/trainer also learns to read whether the horse respects them. Within a herd, hierarchy is established through behaviors such as biting, kicking and rearing. After this, a horse submits to the more dominant horse by moving away [53]. For example, if the dominant horse moves toward the patch of juicy grass, the non-dominant horse moves away. This behavior also occurs in domesticated herds and in horse-human interaction [40]. Movement that gives space to the human, such as moving away when the human walks toward the horse or moving at the pace of the trainer without crowding them, indicates that 'the horse respects the human'. It is a test in early stage interactions for whether the horse and human pair is ready to move to the next level of interaction.

The author observed and practiced this test as part of learning to ride a horse. At the third session with a horse, the journal records that *the theme of today's encounter was "he doesn't respect you yet, he thinks he can do whatever he wants, he is not cooperating".* We were still practicing how to walk the horse without having him crowd the human. In other words, the horse should walk next to the human without getting in their space or tugging at the lead rope. The expert trainer demonstrated that the horse respects her by eliciting a backward movement from the horse. Then, the trainee had to perform a similar test: moving toward the horse and checking how the horse responds. *J-21-06-14: "L faced the horse and walked at him and he walked backward. . . .I was made to practice this too. I had to walk at his cheek and make him turn a 360 turn. This was all part of getting him to respect my space."*

The author, while conducting observational work, found an opportunity to confirm the usage of the term "respect" in the context of early stage horse-human interaction. In this group interview, students who were training yearlings, when asked a broad question about respect, listed non-verbal behaviors that are consistent with the riding context. *I-21-10-29: "[Impromptu group interview with students while waiting for class to start.] What constitutes "respect" in the context of horse-human interaction? Don't bite. Personal space. Don't come into my space until I invite them in. (Lots of nods and yeahs on that one.) Get out of my way if I walk towards them."*

4.2 How the *human* communicates with the horse

Humans communicate with the horse with both physical and auditory signals. Beyond the mechanics of the signals, our main findings here are that there is redundancy and hierarchy in the directives that are available to the human. Redundancy and hierarchy allow for communication to be personalized for each human-horse dyad. However, they also create opportunities for mixed signals, especially at the early stage. We elucidate on these findings below.

4.2.1 Humans communicate with their hands, legs and seat position, as well as their voice. Humans use a variety of signals to direct the horse. Signals are physical or auditory or a combination. A rider's hands control the reins, which create pressure on the mouth of the horse through the bit, which is known as direct reining, as well as physical sensation on the sides of the neck, which is known as blocking. A rider uses their legs in a variety of ways: the thighs and calves to squeeze, the heels to kick. Seat position and posture additionally impact how the horse feels the rider's weight and is also a cue to communicate with the horse. In addition to these physical signals, a rider or trainer uses vocalizations such as clucks and smooches, and verbalizations such as "trot" or "whoa" to direct the horse. Just as "whoa" is a signal to stop, pulling on the reins backwards is also a signal to stop. Similarly, a rider may say "walk" to get the horse going, or loosen the reins. In other words, there is a level of redundancy built into the set of directives.

4.2.2 Avoid mixed signals. Because the horse perceives and processes multimodal input from the human, a common challenge for early stage riders and trainers is to avoid mixed signals. For example, if the rider says "walk" but does not loosen the reins, the auditory signal directs the horse to move forward but the physical signal (tightness of reins and consequent bit pressure) direct the horse to remain stationary. The author found herself giving mixed signals when trying to get her horse to walk along a curve. *J-21-06-14: "I used the neck of the horse as the orientation vector. But then he did stuff like turn his neck but keep walking in the same direction that he was going. To some extent (a large extent) it was because my cues were ambiguous – I would pull the right-hand side rein but not release the left rein when trying to turn him...She said that when I give him ambiguous signals, he picks the one that he likes better. So, for example, if I say walk but don't loosen the reins, he'll get two signals and just choose to follow the one that allows him to stop."*

In the horse training class, the instructor worked with a student whose horse was not listening to her. The goal of the session was to have the young horse circle in the round pen, going from a walk to a trot to a canter and then back. The student used verbal signals but was not clear in the verbalization. *O-21-10-29: "Then he asked the student to slow the horse to a walk. The student said "whoa" and was immediately corrected "don't use whoa. You can say easy if you want. But whoa is for a complete stop.""*

4.2.3 Be as gentle as possible, as firm as necessary. We found that in addition to redundancy, there is also a hierarchy in the signals used. The human starts with the gentlest possible signal and escalates the intensity of the signal as needed. This trainer demonstrated escalation through the reins when the goal is communicate to the horse that the human wishes to go straight, not turn right. *J-21-08-30: "Blocking means 'please can you go this way', kick means 'remember we're going this way', direct rein means 'hey you this way NOW'."* Blocking refers to placing the right reins such that they gently touch the side of the horse's neck indicating to him that he should not turn. An alternate, higher intensity signal is to apply heel pressure on the right side flank to indicate that it is not time to turn right. Direct rein refers to pulling the left side rein to communicate that a right turn at this time is undesirable. It is the strongest signal because the horse's mouth is the most sensitive part of the body that is leveraged for physical signalling.

4.2.4 Different horses need different handling. Different people have their own preferences. Horses are bred for different traits. A ranching horse is bred for quickness and "cow sense", which refers to the ability to intuit where the cattle will move next and respond appropriately. Dressage horses are bred for sensitivity while race horses are bred for speed. Arabian horses are famously bred for endurance, a characteristic of physique, and loyalty, a characteristic of temperament. Even with breeding, there is individual variation in temperament and training. As a result, riders and trainers learn to handle each horse slightly differently. Redundancy and hierarchy create opportunities for this to be done.

J-21-08-16: "this is a forward going horse, which means that unlike Irby, who stops at the shortest notice, this one will go forward very

Table 2: How the *horse* communicates with the human

Prevailing equestrian knowledge base	Interpretation through the lens of HRI	Example(s) from field notes
Horse language is body language.	Expressiveness in this intelligent agent is dominated by nonverbal cues.	*When he saw a deer, his **whole neck and head came up** and his ears were up. ... The student trainer was...waving a flag...[The horse's] **ears were following the flag**.*
The horse must respect the human. In a herd, a horse moves out of the personal space of the more dominant horse. A ridden horse similarly gives space to the human.	At the earliest stage of the human-agent interaction, humans test for respect before training or testing for obedience and trust.	*Impromptu group interview with students because the instructor was running a few minutes behind. What constitutes "respect" in the context of horse-human interaction? Don't bite, **Personal space** –> don't come into my space until I invite them in –> lots of nods and yeahs on that one. **Get out of my way if I walk towards them.***

easily. In contrast, I need to be firmer about whoas. With Irby, I rarely have to whoa. With JJ, I had to just barely press my leg to his side and he started walking. And not walking the way [the other horse] does, but walking with a purpose, as if we have somewhere to be; He turned with slight rein movement, so I could learn what a block is – when you use the outside rein to "push" instead of the inside rein to pull. We weaved through the traffic cones quite easily, a lot more easier than with JJ. I learned how to use leg pressure instead of reins to get him to turn."

This journal record illustrates the difference in the signaling strategy for two different horses. When working with a horse that is bred for forward movement, the rider finds that the horse starts moving with a subtle signal but needs a stronger signal to stop. Not just horses, no two humans are exactly alike either. In the context of human-horse interaction, the differences between humans that make a difference to communication are physical characteristics such as height, weight, leg length (all of which impact where on its body the horse feels the human's signal) as well as differences in balance, timing and feel [51]. Additionally, humans have different personality traits such as being talkative or quiet. This individual variation results in differences in the signals humans prefer to use, or find effective. Multi-modality and redundancy in directives allow the human opportunities to explore different signaling strategies and then settle on a personalized protocol. For example, *O-21-10-29: "...some people talk more to their horse, some would rather use leg others would rather say "walk"."* A horse-human dyad thus uses a personalized communication protocol: *"Students called out words their horses could understand "I had one that slowed down when I hum" or "I had one that understands no" ... "if I made a mistake with this one horse, he would buck or do something so everyone knew"."*

4.3 How the human proceeds in the face of an undesired outcome

Though a human may send their signal or directive, the outcome may not be one they desire. We found that when this happens, the human must learn to read their horse as well as their own self. We illustrate these two aspects below.

4.3.1 Effective riders/trainers try to figure out what caused the horse to respond the way it did. The horse is an autonomous agent and has an internal state and internal motivations, such as being hungry or tired, in addition to external motivations, such as the rider's leg pressing on his side or a sudden noise. When the outcome is not the one desired by the human, a debugging frame of mind is required. The human gets curious about why the horse is responding the way it is rather than resorting to force to dominate or coerce. This journal entry records a day when the horse was walking along the arena but stopped without an apparent reason. The human evaluated the environment and noted that the horse stopped next to a pole that looked just like the one they had used in the previous exercise. *J-21-10-04: "He went and stopped in front of a pole on the side of the rail. It was the same kind of pole used in the rope gate exercise. He recognized it and stopped just as if we were doing that exercise. A false positive, but a reasonable one."*

This debugging frame of mind needs to be nurtured as it may not come naturally to every equestrian. The author visited an expert horse trainer who explained his debugging strategy. This trainer had his own farm and training facility where he worked with high value thoroughbred horses. Horses are brought to him when they 'have a problem', i.e., they are not responding to the human's directives. He goes back to easier directives till he finds one where the outcome is as desired. Then he works his way up step by step to the case that presented the problem. *I-21-03-03: "F was on a horse as we walked in and we talked as he worked the horse. He fixes horses. Racing horses that were bought for a hundred thousand dollars or more but now won't go into the race track or will buck their riders. As we talked, it became clear that what he was doing was debugging and retraining the horse. He talked about how if the trainer brought in the horse because it wouldn't canter then F would ask him: did you walk it? And the answer would be no. Well, then let's walk it. So, he goes back to the simpler cases: walk in a pen, walk between two parallel bars, walk between parallel bars in a curve, walk in a circle."*

Once the expert trainer has 'fixed the problem' by re-training the horse, he sends it back to the riders and trainers that own the horse. If they do not adopt a debugging attitude to reflect on what they might be doing to play a role in the undesired outcome, the horse ends up coming back to him with the same problem. *"But, he said, he can retrain the horse and send it back and only hope that the riders and trainers on the receiving end will also change what they do. Otherwise the horse ends up coming back to him. And there*

Table 3: How the *human* communicates with the horse

Prevailing equestrian knowledge base	Interpretation through the lens of HRI	Example(s) from field notes
Humans use their hands, legs and seat position, as well as verbalization and vocalization.	The human communicates via multiple modalities to direct the horse. Redundancy is built into the set of directives.	*How do you get him to go faster? "Sound of whip, smooching, pressing on sides"; We practiced walking. Hold the reins forward i.e. keep it loose ("that's like putting him in gear"), kick and say 'walk'.*
Avoid mixed signals	Redundancy means that two modalities can give the same directive. But they can also give opposing directives.	*I used the neck of the horse as the orientation vector. But then he did stuff like turn his neck but keep walking in the same direction that he was going. To some extent (a large extent) it was because my cues were ambiguous – I would* ***pull the right-hand side rein but not release the left rein*** *when trying to turn him.*
Be as gentle as possible, as firm as necessary.	There is hierarchy built into the directives used by the human.	***Blocking*** *means 'please can you go this way',* ***kick*** *means 'remember we're going this way',* ***direct rein*** *means 'hey you this way NOW'.*
Different horses need different handling. Different people have their own preferences.	The cues used by a human-agent dyad are specific to that dyad. Redundancy and hierarchy in the set of directives allow for a personalized communication protocol.	*L told me that this is a forward going horse, which means that unlike Irby, who stops at the shortest notice, this one will go forward very easily. In contrast, I need to be firmer about whoas. With Irby, I rarely have to whoa.* ***With JJ, I had to just barely press my leg to his side and he started walking.*** *And not walking the way Irby does, but walking with a purpose, as if we have somewhere to be…He did not "list" toward the center, nor did he have as strong a "spring" that pulled him toward L.*

are only so many times a horse can be retrained before there are so many leftover pathways in his brain that there is no way to make it a clean slate. To that extent, the greatest chance of success occurs when the horse and the rider/trainer each change a little bit. The horse is retrained to follow signals and achieve balance. The rider must change how she rides too- how she shifts her weight, holds her body, when she uses the reins, inner thigh pressure and spurs."

4.3.2 The horse can sense when you are nervous or tired or distracted. Forget your worries. Overcome your fear. An old adage in horse-human interaction is that the horse reflects the rider. In other words, when the rider is nervous or frustrated or distracted, they will find that the horse is not following their directives. For example, in this ground work exercise, the author as participant-observer has to take the horse into a round pen. The goal is to have the horse circle in the round pen, going from walk to trot to canter in the direction indicated by the human. The exercise is complete when the horse and human have successfully done a couple of rounds in the clockwise and anticlockwise direction. *J-21-10-18: "I swung the bridle on my shoulder and then it was time to take him out into the round pen. I had a bright purple whip with me. My job was to get him to go around in a circle. Any time it looked like he was stopping, I had to get near his rear end and raise my whip. Just raising it so he could see it was enough. To do this I found that I had to walk around in a slightly smaller circle than him. I then had to make a kissing sound to get him to go into a lope (canter)."*

The author has limited success in getting the horse to consistently move in the direction she wants and at the speed she wants. The horse starts well, but quickly slows down or makes the circle tighter, entering the space of the human. She wonders why the outcome is not what she desires. The expert trainer suggests that she is not convincing in her signaling. The early stage rider reflects on her internal state and how it could impact her body language and therefore her signals to the horse. *"It took quite a bit of kissing to make JJ lope. Even so, he wouldn't stay in it. I wondered out loud if perhaps he could not hear me. [The expert rider] thought it was because "he didn't think you mean it". I could see that – initially, he stayed at the edge of the round pen, essentially running the largest possible circle, but over time he started making that circle smaller. I did not entirely know how to send him back and so he just kept making it tighter till I raised the whip. Initially I was 100% alert, but then after some time, I mistakenly thought oh he's doing it, I can relax now, and the moment I thought it, it must have shown in my body language, because he started slowing down, stopping and getting some grass to eat, running tighter circles."*

In the next session, the author is more focused on the exercise. She is more alert to the horse and to her own body movements and gestures. She finds that this change yields better success in the round pen exercise with the same horse as before. She still needs to work on her signaling – if she goes too fast and comes up ahead of the horse, he turns instead of keeping the speed steady. However, she has made progress in convincing the horse that "she means what she is saying". *I walked him to the round pen, took off the lead rope and then got him to go round. I had better success this time in keeping him going – today there was only one time that he stopped and snacked on the weeds. I was more alert and focused because I had finally understood how little of a shift in focus would be taken advantage of. Also I had learned better how to maintain my own circle so that I kept a steady distance and bearing with respect to the horse. I had to keep myself and my whip pointed to just behind the stirrups. If I came up ahead of him, that was the way to make him turn.*

5 DISCUSSION

The horse, in many ways, is the kind of teammate and companion that is the holy grail for co-bots and social robots. Yet we must acknowledge that horses are living creatures shaped by evolutionary forces; humans 'found' them rather than 'created' them. And even though humans have tried to breed for desirable characteristics, they are not designed from scratch to serve a specific purpose. This

Table 4: How the human proceeds in the face of an undesired outcome

Prevailing equestrian knowledge base	Interpretation through the lens of HRI	Example(s) from field notes
Effective riders/trainers try to figure out what caused the horse to respond the way it did.	A debugging frame of mind is required not only during the development of an autonomous agent but also during human-agent interaction.	*. . . if the trainer brought in the horse because* ***it wouldn't canter*** *then F would ask him:* ***did you walk it?*** *And the answer would be no. Well, then let's walk it. So, he goes back to simpler cases:* ***walk in a pen, walk between two parallel bars, walk between parallel bars in a curve, walk in a circle.***
The horse can sense when you are nervous or tired or distracted. Forget your worries. Overcome your fear.	The agent senses affect and emotion. The human's confidence, fear, fatigue, distraction, etc. impact how the agent responds to the human's directive.	*One horse was not doing such a good job listening. Again, I heard the use of respect "I'd like for him to show you a tad more respect" – J said to the student. He then told her she had to keep the same distance from the horse. If* ***she got tired*** *or her arm (holding the whip) got tired, the* ***horse noticed*** *and would then test her by* ***looking away or slowing down*** *from the canter/trot.*

lack of absolute control over the design of the agent possibly restricts the ways in which a human can interact with it. Most readers will readily align with the viewpoint that every aspect of a robot can, in principle, be designed and as such, humans are not restricted in quite the same way with respect to interaction.

In practice, however, when an individual such as a worker or a consumer interacts with a robot in the work, home, school, therapy context, they will "get what they get". The size, shape, range of motion, interaction modalities, level of intelligence and so on will be a result not only of the design team's vision, but also engineering constraints such as battery life and weight limits, and corporate constraints such as budget and marketing. Consequently, design guidelines drawn from insights about human interactions with other 'found' agents will be highly relevant for HRI. The findings from our study of horse-human interaction surface several design guidelines for the early stages of robot-human interaction as well as several thought-provoking ethical considerations.

5.1 Design Guidelines

Each finding was reviewed and considered for potential implications for human-robot interaction. The implications were concretized as an instantiation within a context. A variety of contexts were considered, ranging from personal autonomous vehicles to delivery drones, therapy robots for older adults with cognitive impairment to warehouse robots interacting with unskilled workers. Implications were broadly clustered, and two categories emerged: technical and sociocultural implications. The specific instantiations in each cluster were then generalized into design guidelines. This process yielded three categories of design guidelines: behavior primitives for the agent (guidelines (1) and (2) in Figure 2), guidelines for communication between the human user and the agent (guideline (3) in Figure 2), and goals for training/educating the human user (guidelines (4) and (5) in Figure 2). In Table 5, we provide the guidelines in the same order as Figure 2. Additionally, we provide some of the instantiations we considered so as to allow the reader to visualize the types of examples we used in our process. The instantiations are categorized as bio-mimicry and bio-inspiration.

As an example, one of our findings (from Table 2) is "Horse language is body language", which when interpreted through the lens of HRI can be thought of as "Expressiveness is dominated by nonverbal cues." The obvious implication would be that we should design non-verbal behaviors for social robots. This, in itself, is not new to HRI. When we consider this in the context of the second finding in Table 2 we arrive at the novel implication that non-verbal behavior primitives should be designed to express respect. We further consider this implication in the context of the work done on human-robot proxemics which for the most part implements human-human proxemic rules [45, 55, 61, 66]. This naturally brings up novel future scenarios where such behavior primitives might incorporate human-animal proxemic rules. In Table 5, the first example for this design guideline is in the bio-mimicry vein, where the robot follows the personal space rules that a horse would. The second example is bio-inspiration: just as horses give space to the more dominant horse, we consider a context where different robots are competing for the same space, for example, a delivery drone and a sidewalk delivery robot reach the same address at the same time. There is possibly some protocol for negotiating priority after which the robots communicate the result of the priority negotiation through giving up space.

During the development process of the design guidelines, implications that were not novel or not generally applicable in different contexts were discarded. For example, from our analytical notes: "Vocalizations such as cluck and smooch may be useful auditory signals as they are not used in daily conversation; repetition is needed for the AV to learn the audio signal – might simulate various scenarios in which driver will say "whoa" so as to learn the different tones and volumes in which it may be said [5/26: this is not new]." Though leveraging the full capacity of human vocalization to interact with robots may prevent dangerous false positives such as the autonomous vehicle stopping when a child in the back seat yells 'Stop' to their sibling, it would result in a suite of special purpose verbal codes, no different from special purpose tactile codes such as swipe and double-click. The next implication in this same excerpt, repetition, is not novel either as speech processing algorithms have long created such training databases.

5.2 Ethics

Consent Increasingly, the sub-field of HCI known as ACI is advocating that the research community consider animals as stakeholders in the research process [47, 49]. For example, one of the issues raised in ethical ACI is the process of consent. In this research

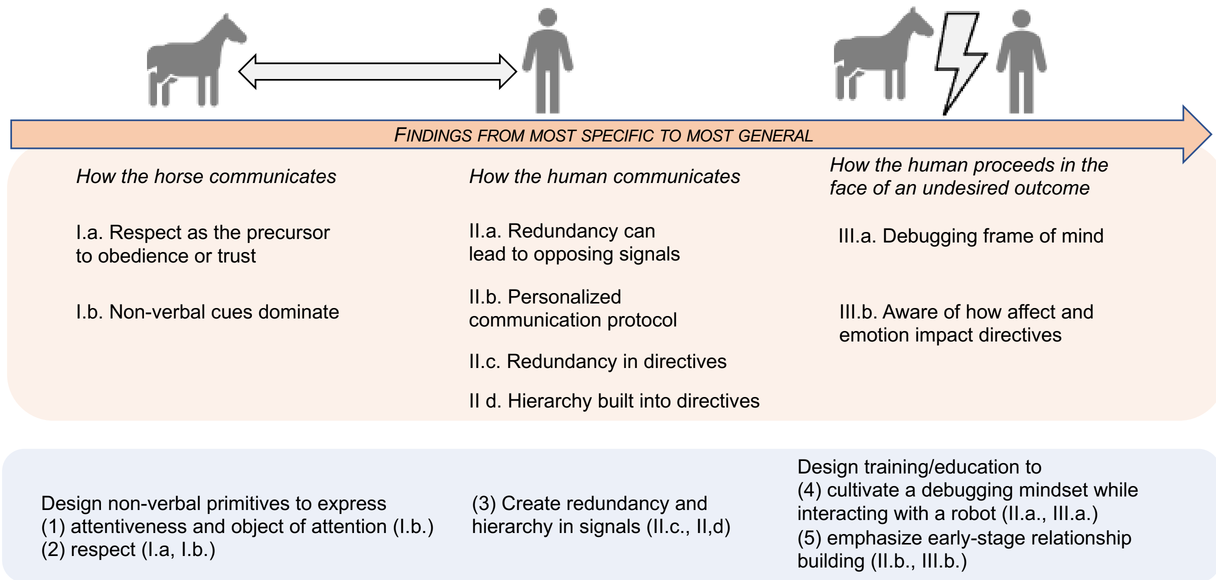

Figure 2: We illustrate how the findings from Section 4 connect with the design guidelines in Section 5.1.

study, our approach was what is defined as mediated consent by Mancini [38]: the daily caregivers of the horses provided consent.

Rights and well-being Animals have rights, and as of the writing of this article, robots do not. For example, it is considered reasonable to kick a horse with the heels while riding it, but it will be considered abusive to draw blood in this process. The outcomes of our analysis include findings that point to an ethos that places animal well-being foremost, such as taking a debugging approach rather than resorting to force when the horse does not perform as expected. It is, therefore, possible that granting and upholding these rights restricts the ways in which humans interact with horses. The debate on whether robots should have rights went from a purely academic discussion [14, 15, 24, 25] to the real world when the EU Commission on Artifical Intelligence and Robotics recommended that a "specific legal status" be created for "sufficiently advanced robots" and an open letter to the European Commission then pushed back on this recommendation [17, 25, 64]. In response, De Graaf and colleagues conducted a public survey to solicit lay person opinion and found that younger respondents (<30years of age) and those who worked in engineering were quite willing to support robot rights related to functional needs such as the right to updates or right to energy [17]. Indeed, young children are reported to be arguing for their home robots to have "rights" such as not being in the closet when everyone else is outside [58]. Darling, a legal scholar by training, has argued that it may be beneficial to grant legal rights to robots, e.g., to prevent humans from abusing robots, because it will reinforce the standards of conduct a society has for the humans belonging to that society [15]. Parents of young children are already concerned about the lessons their children are internalizing if they speak rudely to a voice-based agent in their home [26]. So even though robots such as the ones mentioned in Table 5 do not have rights, such as being safe from abuse, at this moment in time, lessons from human interaction with agents that do have such rights will have relevance for users of those robots.

6 LIMITATIONS

Limitation: Sample Size Because of the novelty of the horse metaphor, our study activities are naturally exploratory. The goal is to uncover, as broadly as possible, the ways in which human-horse interaction could inform human-robot interaction. As a result, our sample population is relatively limited in terms of both size and diversity. Future work could employ semi-structured or structured techniques to elicit more information from larger samples. Another interesting future work direction could be to go deeper, for example, research by design where equestrians and engineers co-design highly automated vehicles or exoskeleton robots.

Limitation: Paradigm Bias Even with larger sample sizes, there remains a paradigm bias: our study activities are based in the Euro-American tradition of human-horse interaction. Concepts such as respect, the place that a horse occupies in a human-horse team (in the work context) and in the family (in the companionship context), are a product of the world view of the humans involved. While we could not alleviate this bias for this first study, we made an effort to recognize it and perform an initial probe following Strauss' approach of compare-and-contrast. We interviewed a scholar whose doctoral dissertation examined lessons learned from horse-human interaction for decolonizing education. This scholar, currently a faculty member at the Gender and Women's Studies and American Indian Studies Programs at a major university, trains horses at her family ranch using methods informed by her father's Navajo (Diné) tradition of horsemanship [30]. We discovered, for example, that in this tradition, a human would ask a horse if it is okay to ride today rather than walking in with that expectation. Horses are regarded as relatives, a distinctly different view of the human-horse

Table 5: Design guidelines and potential instantiations.

Design Guideline	Example 1 (Bio-mimicry)	Example 2 (Bio-inspiration)
Design non-verbal primitives to express attentiveness and object of attention	An assistive/therapy robot for an older adult with hearing impairment has prominent ears that point toward the human user when it is listening to them and toward the door when it hears a knock.	A Level 3-4 autonomous vehicle has a row of colored lights on the dashboard to communicate to the driver where it detects a pedestrian; if the detection is a false positive (e.g., boxes piled on curb), the driver can override the autonomous vehicle similar to a rider giving a horse a squeeze with the legs to ignore the deer and keep moving.
Design non-verbal primitives that express respect	A delivery robot in a hospital or retail store mimics the personal space 'rules' that horses follow, for example, moving at the pace of the staff or customer without crowding them. Walking side-by-side with starts and stops is a test used to determine deployment readiness.	A delivery drone and a wheeled sidewalk delivery robot both reach the same address. They use cues such as size or type for determining the dominance hierarchy. The less dominant robot gives space to the more dominant robot.
Create redundancy and hierarchy in signals	A Level 3-4 autonomous vehicle stops behind the vehicle in front but is too close to that vehicle for the human's comfort. The next time, the human says "Brake" to get it to start braking sooner; if that does not work, the human can tap the brakes or say "BRAKE!" or do both together. The vehicle is designed to sense and interpret the increasing intensity of the human's directives.	A co-bot in a factory is holding out a part that the human is detailing. The human verbalizes "Closer" for the part to be brought closer, or pulls it closer with their hands to indicate that they want it closer, or does both together to emphasize their request.
Design training/education to emphasize early-stage relationship building	A pack-carrying robot is put on a real or virtual longe line (e.g., a set distance that it must maintain from the human based on radar sensing). The human learns how to teach the robot to walk alongside the human via a start, stop, speed up, slow down exercise. The human learns that this exercise is specific to the human-robot dyad so that the robot fits to the human it will work with.	A human worker and a co-bot in a warehouse or a factory hand a box back and forth N times so that the robot learns what this worker's posture is like when they are ready to hand over something. This repetitive task is reframed as early-stage relationship building instead of calibration to mitigate worker boredom on one hand and contempt for the robot on the other hand (stupid robot, now I need to hand it a box fifty times so it knows how to take a box from me).
Design training/education to cultivate a debugging mindset while interacting with a robot	It is a dark evening and the mobility impaired adult's robotic exoskeleton stops suddenly. Without a debugging mindset, the human simply moves up in the hierarchy of directives, overriding the robot till it moves forward and tips over. With a debugging mindset, the human assesses why the robot did not follow the directive to move. Is there something blocking their path? Has the robot's radar sensed a sudden drop in the terrain? Have they reached the site they needed to reach?	Two mobility impaired older adults go for a hike on their robotic exoskeletons. One adult finds that his exoskeleton consistently pulls toward his friend, too close for safety. Without a debugging mindset, the friends abandon their hike and post a complaining review about the product. With a debugging mindset, the older adult assesses: could he be leaning toward his friend to talk and the exoskeleton interprets the posture as a directive to go closer? Perhaps on this windy day the robotic exoskeleton is sensing the optical flow on the bushes lining the hiking trail as if they were vehicles coming toward it? He tries adjusting his posture and switching sides with this friend.

relationship [19]. Becoming aware of, and incorporating, diverse world views could not only inform the design of interactions with robots, and influence how we as a society approach the integration of robots, but also influence philosophical aspects of HRI such as rights of robots themselves [14, 17].

It would indeed be interesting to examine human-horse teamwork and companionship in different cultures around the world, including the Mongolian, Marwari and Arabian traditions of horsemanship. We attended the 67th Annual Scottsdale Arabian Horse Show in Phoenix, AZ concurrently with this study. Over two thousand horses and related humans gather in a dedicated 150 acre facility to compete for more than a million dollars in prize money. Though the bloodline of the horses has its origins in Arabia, the culture of horsemanship is now largely Western. Given how prized these horses are for their endurance, loyalty and sensitivity, future work could aim to uncover traditional knowledge in the Arabian context and examine differences in interaction patterns compared to the European/American context.

Limitation: Scope Finally, the scope of our field work and subsequent thematic analysis has been the early stages of horse-human interaction. It would be interesting to examine the stages that come before and after. For example, the pre-interaction stage: students in the horse training class had to select the horse they would work with for the rest of the semester; when asked why they selected a particular horse, answers ranged from how the horse responded to them when they walked it to impressions such as 'cute' to 'quirky personality'. Exploring this aspect further could inform the computational design of first impressions [7]. It would also be intriguing to examine later stage interactions, when the working relationship has been established and the goal is to improve performance. For example, task-specific interactions between highly trained horses and highly trained riders in the different disciplines of racing, dressage and ranching could inform design thinking around highly automated exoskeletons and co-bots in dynamic environments.

7 CONCLUSION

Our work addresses two knowledge gaps in HRI: the first gap is in early-stage HRI, specifically, how to build a working relationship between humans and robots; the second gap is in lessons from human-animal interaction (HAI), specifically, what we can learn from other animals that have had, and continue to have, a close working relationship with humans. Our main contribution is to address these two knowledge gaps through the study of human-horse interaction. Our year long qualitative study of human-horse interaction provides insights into communication between humans and horses at the earliest stages of their working relationship. While the observations themselves may seem basic to the equestrian, they are thought provoking to the HRI researcher. The findings inspire novel research questions: how should a robot express respect? how would we design redundant and escalating directives in different HRI contexts? Novel tradeoffs emerge as a result: redundancy in directives creates affordances for personalized communication, but also opportunities for mixed signals, especially for inexperienced human operators. Finally, the observations compel us to take responsibility for what we bring to the interaction and ask: what kind of attitudinal shifts and educational goals should we incorporate into worker training at the earliest stages to make it both pleasant and productive to work with a robot?

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