Present-at-*Body* Self-Awareness in Equestrians: Exploring Embodied ‘Feel’ through Tactile Wearables

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Abstract

We are interested in novel interactive uses of pressure sensors and vibration actuators that can augment the role of physicality for embodied human perception and experience. Specifically, we explore how wearable technology can be used to provide more *realistic* present-at-body self-awareness in equestrians. Self-awareness of a rider’s own physical cues (output) and how a horse responds (input) requires practice to attain *objective* adjustment. In this paper we present a proof of concept prototype aimed at providing ways to bridge the gap between rider output *perception* and *reality*. Our prototype couples pressure data gathered at specific points of the body in real-time with non-audiovisual tactile vibration feedback that is also site-specific. Our design is intended to enable an *effective way for riders to learn about asymmetries in seat-related pressure by providing a present-at-body self-awareness of pressure points*.

Author Keywords

Wearable; Sensors; Horseback Riding; Self-Awareness; Embodied Interaction; Human Perception.

"The basic demands to be made of a good seat, to be balanced, straight, and supple are very simple. But how do we get there? The first stumbling block that the student runs into is that the calibration of his body awareness is more or less out of sync with objective reality… For instance, when the student feels straight, he may actually be tipping forward, collapsing in the waist, and sitting more on one seat bone than the other. When the teacher then makes adjustments to the seat, so that the student really is straight… he may feel as if were about to fall off… This is one of the most disorienting phases in the student's training, yet we have all gone through it at one time or another. It is also one of the most crucial lessons every student has to learn… We have to make our own body awareness coincide with reality, so that objective straightness actually feels straight to us, while crookedness has to feel crooked" [1]

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

We focus on ways to bridge the gap between rider action *perception* and action *reality*. In horseback riding 'feel' (e.g. contact with the horse through the legs, bottom or hands) refers to a quintessential embodied experience. It's an experience where "the feel of the muscle tensions, the touch of the skin, the tonicities of the body, balance, posture, rhythm of movement, [and] the symbiotic relationship to objects in our environment" [6] all play a *personal* role in *what* and *how* a rider learns.

As pointed out in the sidebar story, 'feel' is a subjective experience for all riders – "Only the social actor producing the touch and feeling the response can really know how he or she touched and how the response felt" [5:16]. This *touch/response-feel* process put forward by Norris, must be learned and in riding, "verbal teaching, explaining and relating take on a big role" [5:8]. But what does 'feel' even mean? How do I know when I've felt 'it'? How do I relate 'feel', as explained by someone else, to what I'm feeling?

For inexperienced riders, there is a conscious effort to 'do' with the body similar to Heidegger's 'present-at-hand'. But, we argue that the 'tool' in the rider's case becomes more complicated. 'Tool' is expanded to a 'present-at-*body*' experience. A rider must think about her *whole body as a tool* in addition to the equipment interfacing with the horse. As a rider progresses in body awareness and control in connection with the real-time feedback from the horse, the more the act of riding becomes *tacit* knowledge, as first introduced by Polanyi. At this point riding becomes a 'ready-to-hand' – or 'ready-to-*body*' – experience. During these moments the horse and the interfacing equipment become a literal extension of the rider while she simultaneously becomes an extension of the horse. These moments of flow move the riding experience beyond "the equipment [fading] into the background" [2:109] and into a 'Centaurian' experience [3].

The problem is when a rider's perception of the physical self is not in alignment with an observable objective reality. Thinking of the body as a tool allows one to act with intention, but the *perception* of what is being done and how it is being executed may not be what is *actually* happening. We are interested in how wearable technology can be used to provide more *realistic* present-at-body self-awareness. Specifically, we created a wearable proof of concept prototype to explore the following research question: *Can wearable site-specific vibration feedback, coupled to site-specific pressure input, provide an effective way for riders to learn about asymmetries in seat-related pressure by providing a present-at-body self-awareness of pressure points?*

Problems with Existing Interventions

Common strategies exist to help riders create a more realistic present-at-body self-awareness. Physical intervention (e.g. physically repositioning the rider) or place swapping (e.g. student dismounting and trainer getting on the horse to demonstrate) are both regularly employed. But there are some issues with these existing approaches.

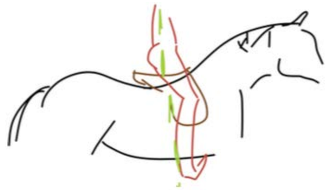

Figure 1. A balanced seat requires symmetry in weight distribution and pressure as well as maintaining the correct vertical alignment. Ideally, there's a straight line from the crown of the head to the shoulder to the hip to the heel. If alignment is correct, an unbalanced seat may be the result of asymmetrically distributed weight and pressure between each side of the seat (Left and Right side of body).

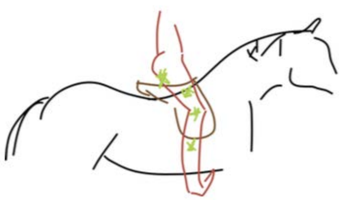

Figure 2. A side view of the areas of the 'seat' used to gather pressure data as well as provide site-specific vibrotactile feedback. At these points, pressure (FSR) sensors will be mounted on the inside of a rider's leg and the vibration (ERM) motors will be mounted to the outside.

They're not dynamic/real-time. With physical intervention, a rider is stopped, positioned in the static and then asked to 'hold' that position once movement begins again. With place swapping, riders are literally no longer on the horse. A rider must watch and hopefully absorb what's happening – enough to reproduce the actions or position once remounted. Additionally, a rider must somehow relate this back to what she *thinks* she is doing or not doing, which may not be in alignment with objective reality to begin with.

They're not persistent. Often riders, especially those who own or lease their horses, are not always in lessons when they ride. This means that there is time between lessons where a rider is left to train on her own. But, how do you know if you're really correcting yourself? There's a difference between 'feeling' like you're doing something correctly and actually doing it correctly. It can be very hard to improve when there isn't external intervention because body perception can actually be incongruent with reality. If a rider hasn't 'retrained' her mind and body to know what embodied feeling *feels* and *is* correct, it becomes nearly impossible to progress.

Typically, these interventions are accompanied by verbal 'metaphor' to further teach a rider what to do. The learning process of riding requires the articulation of a trainer's embodied knowledge to the student. The rider must interpret this verbalized 'feel' and integrate it into her own understanding of self. Once a rider is more advanced, these articulations prove quite useful because there is a common language understood by both rider and trainer (embodied and verbal). However, for young and novice riders, metaphor often doesn't lead to more clarity. A trainer, John, illustrates the difficulty with metaphor: "how do you communicate a feel from one person to the next? It's like trying to describe a smell you've never smelled before. Smells like an orange, well I've never smelled an orange. Well, what do they smell like? Well they smell like a grapefruit, well I've never smelled a grapefruit, but sweeter, but…" [5:9–10].

Prototypes have been created to provide 'objective' metrics for both self-awareness and communication about rein tension (e.g. [10]). Tension sensors were attached between the bit (what's in the horse's mouth) and rein to provide 'objective' metrics for the rider and trainer to discuss the mouth-contact-*feel* (e.g. how much contact is enough, asymmetries between hands, etc). Tension data was recorded for each rein on a laptop and visual feedback was given to the rider in real-time via LEDs placed behind the horse's ears. These interventions provide information that could be used for physical self-awareness, but they are typically used to improve animal welfare (e.g. how rein tension can have negative impacts for the horse). Though we agree that these ethical considerations are important, we argue that a focus on human body self-awareness subsumes these goals. While hand-mouth-feel is an extremely important part of riding and a hard skill to learn, "an independent or balanced seat is [a] pre-requisite for good rein control… A balanced seat allows you to release and increase rein tension very precisely, so you can clearly define your cues and reinforcements regardless of what your horse is doing" [10]. See Figure 1 for 'ideal' seat position.

Additionally, a recent paper [9] contributes a framework and large scale deployment study that measures horse movements for Dressage. While this

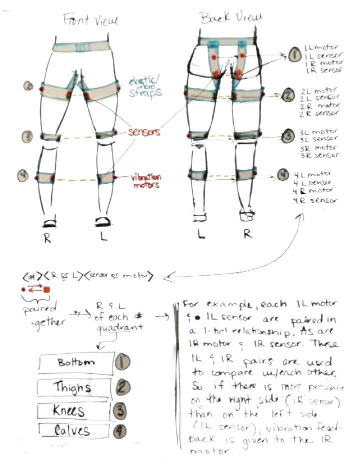

Figure 3. Sketch of components (FSR, motors, straps) based on quadrants. Three ESPs and batteries are used to power location-based components: (1) quadrant 3&4R, (2) quadrant 3&4L, (3) quadrants 1&2L + 1&2R. This keeps wiring minimal, which was a 2nd order safety-related design requirement.

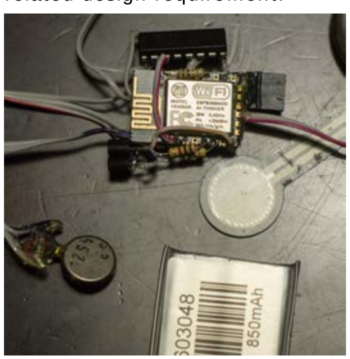

Figure 4. Basic hardware set up for (1) quadrant 3&4R.

could provide feedback to riders about how their actions correlate with the quality of horse movement – the inferences would have to be made post hoc and rather indirectly (e.g. I can compare changes in horse movement and attempt to relate it to what I did). It's not intended to directly aid rider changes in real time.

Unfortunately, "rider asymmetry has received little attention in the scientific literature, most likely due to the difficulties in measuring the interface between horse and rider" [8:34]. Wearable technology offers a unique way to explore this problem space. The prototype we present explores how wearable technology can be used to provide more *realistic* present-at-body self-awareness. See Figure 2.

Prototype Overview & Design Requirements

Since the seat is the foundation of balanced riding, we built a prototype to explore how real-time and persistent pressure sensor technology can provide better self-awareness of asymmetrical seat pressure points. We used eight force sensitive resistor (FSR) pressure sensors positioned in the following quadrants: (1) seat bone, (2) inner thigh, (3) inner knee, and (4) inner calf. These objectively measure asymmetries within the 'seat' (pressure input). Each FSR is paired with an eccentric rotating mass (ERM) vibration motor that is positioned on the 'outside' of the body to provide site-specific feedback (vibration output). The prototype uses three ESP8266 WiFi Modules for control and wireless communication. This reduces the amount of wiring between seat quadrants as well as provides the ability to transmit data wirelessly. Three 850mAh Lithium Polymer batteries power all components and were chosen for their slim, lightweight design. See Figures 3 & 4. To address the major pitfalls of the problem space, our 1st order design requirements were:

1. Real time & persistent (input + output)
2. 'Objective' measurement mechanisms (input)
3. Feedback mechanism(s) that aligns with application context (output)
4. Site-specific pairing to create a tight coupling (input + output)

Design Rationale

We wanted to provide *persistent and real-time* feedback. This was important because most existing interventions come in the form of verbal and physical feedback in 'frozen' moments of time. Allowing for real-time and persistent feedback provides riders with the ability to adjust their physical actions and mental self-awareness regardless of when, where or with whom riding occurs. To provide real-time and persistent feedback about seat pressure asymmetries (e.g. uneven pressure distribution between each independent side of the seat) that was also *site-specific,* we paired each side of the seat for input and output by quadrant. For example, if a rider applies more pressure with the left knee than the right, the left knee vibration motor will notify the rider in real time about this issue as long as it persists. In the future, this data could be recorded to provide a view of problems and improvements over time. Data could also be sent in real time to an external device via the WiFi enabled ESP modules to aid the training relationship as in [10].

In addition, *objective* pressure measurements can be used to provide an intervention that will hopefully (over time) allow body awareness to "coincide with reality, so that objective straightness actually feels straight" and

Figure 5 (top) & 6. The top photo shows the hardware components that attach to the outside of the leg (ESP, ERM, battery) and the bottom photo shows the FSR location on the inside of the leg.

"crookedness [feels] crooked" [6]. To some degree, the 'sensors don't lie' and will allow a rider to take an 'outsider' view of their balance and positioning.

Furthermore, we needed a *feedback mechanism that was attuned to the requirements of the equestrian context*. Riders must maintain environment awareness at all times. Looking up and ahead helps a rider maintain proper form and keeps her aware of dangers (obstacles, things that may scare your horse, other riders, etc.). Listening is part of training practice and injury prevention. One could imagine feedback in the form of colored LEDs or verbal recordings played via headphones ("your right knee has more pressure than you left"). While visual or auditory feedback seems more 'interpretable', it conflicts with important requirements of the equestrian space. Vibrotactile feedback has been used in many fields to provide awareness alerts as well as site-specific and directional cues (e.g. gaming technology [1] and pilot cockpit awareness [7]). However, *vibrotactile feedback needs tight coupling between the physical input and output space in order to minimize the ambiguity of purely haptic sensory feedback*. We opted for a straightforward mapping between feedback and the bodily placement that was *site-specific*. While the FSRs support site-specific input, vibration motors provide site-specific feedback (e.g. more pressure with your right knee than left? provide vibration feedback to the right knee motor). This requirement was achieved by positioning a single vibration motor at each point of interest to provide a vibrating sensation during pressure asymmetry. See Figures 5 & 6 for basic implementation held in place by elastic Velcro bands.

Discussion

In 'embodied interaction' the actor (the do-er) may use artifacts or the environment as traditional tools to achieve a goal. In the traditional hammer example the goal may be to hang a painting on the wall with a nail. We act on this goal by allowing the hammer to become an 'extension' of our arm and hand (ready-to-hand) and we really only think of the hammer as a tool (present-at-hand) when we, say, hit our other hand holding the nail.

But, embodied experiences like riding allow us to think of the "body as a circuit for both input and output" [4:255] where the goal (and sub-goals) may be *dynamically* changing. In riding, it's really *the body itself* that must be thought of as the tool. What's more, independent aspects of the body may be thought of as a tool (present-at-body) while others continue to 'act' without explicit thought about *how* they're doing what they're doing (ready-to-body). The actor oscillates between present-at-*body* and ready-to-*body* because of an embodied 'jolt' (e.g. whoops that's not the reaction I wanted, I must've done something wrong) or an embodied 'flow' (e.g. this just feels right, "I feel 'canter', 'trot', 'walk' or 'halt' with horsey limbs" [3:8]).

Adding to this, understanding of the 'tool' when it is your own body is not as straightforward as it seems. In riding, there is tight coupling between the input and output 'devices' – a rider gives cues to the horse physically *through* the body and also receives most input (horse reaction) as a physical sensation. To fully understand and have control over one's physical self requires better alignment between a rider's self-awareness of *subjective* versus *objective* movements and positioning. We argue that wearable sensors and actuators provide a unique opportunity to assist self-awareness objectivity. These technologies can provide real-time and persistent objective metrics (e.g. pressure measurements) for comparison as well as ways to give site-specific feedback. The prototype we present in this paper is an exploration of current readily available technology in this conceptual space (e.g. present-at-body and objective self-awareness).

Conclusion

A rider's perception of the physical self and the objective reality of the physical self may be misaligned. The proof of concept prototype we present in this paper is aimed to help riders lessen gap between what they believe their body is doing and what is visible in objective *reality*. We propose that coupling pressure data input with real time, site-specific vibrotactile feedback can enable an *effective way for riders to learn about asymmetries in seat-related pressure by providing a present-at-body self-awareness of pressure points*. Our future work is aimed at iterating on our current prototype through testing with actual riders on and off horseback. This will allow us to more accurately calibrate pressure thresholds as well as the type and duration of vibration feedback. Additionally, future testing will provide a better understanding of the limitations of the current vibrotactile materials as well as further our understanding of rider expectations for these materials in actual practice.

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