ReRide: Performing Lower Back Rehabilitation While Riding Your Motorbike in Traffic

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ABSTRACT
What if a person with lower back problem could perform prescribed exercises while riding a motorbike in city traffic? In this paper we present our ReRide design experiment. The ReRide interactive sketch uses a belt with embedded flex sensor to obtain back posture data, and a microprocessor controlled mechanically moving display mounted on top of the bike's speedometer that alters the visibility of the speedometer to the rider indicating the correctness of back posture. Informed by embodied perception, the ReRide design emphasizes a rapid coupling between adjusting your back posture and the feedback presented thereby extending the bodily interaction with the motorbike already at play when riding to interacting with the self-monitoring technology. ReRide informs work in HCI investigating how, taking embodied interaction as the theoretical foundation, digital technology for self-monitoring can be designed to help integrate physical rehabilitation with everyday activities.

CCS Concepts
• **Human-centered computing ~ Activity centered design** • **Human-centered computing ~ Interaction design theory, concepts and paradigms** • **Human-centered computing ~ Ubiquitous and mobile computing systems and tools**.

Keywords
Physical Rehabilitation, Motorbike Riding, Embodied Interaction, Embodied Perception, Embodied-Self-Monitoring, Rapid Coupling.

1. INTRODUCTION
We observe an increase in interests and efforts bo th from society and individual citizens to move aspects of physical rehabilitation beyond clinical settings into people's everyday lives and settings in general, including private homes. However at the same time, as part of this development we observe widespread reports of lacking rehabilitee adherence to the prescribed rehabilitation regimen when at home [4], leading to rehabilitation programs with poor performance.

In brief, looking for ways to address low levels of adherence to prescribed physical rehabilitation [4], the field of physiotherapy is moving towards a more individualized approach considering the particular life circumstances of the individual rehabilitee when defining an appropriate rehabilitation regimen (for e.g. [9,10,11]). Promoting this move is a widely accepted working hypothesis within rehabilitation research that the integration of physical rehabilitation exercises with mundane everyday activities of the individual rehabilitees will lead to better adherence and hence, in turn result in more successful out-of-clinic rehabilitation programs [10,11].

In our previous work [1,2] we take this hypothesis from the field of rehabilitation research as the ground for an interaction design research question and challenge: How can we design mobile&pervasive digital technologies to help rehabilitees and therapists in turning mundane everyday activities into parts of a prescribed regimen for physical rehabilitation? Taking embodied interaction [5] as the theoretical foundation, we [1] proposed 'embodied-self-monitoring' as a theoretical construct that may help guide interaction design for everyday physical rehabilitation performed in settings beyond the clinic. We defined 'embodied self-monitoring' as: Measuring, recording, observing, and performing other such self-monitoring actions through actively engaging with the particularities of a setting for adhering to prescribed treatment or therapy.

We understand designing for embodied self-monitoring as designing mobile&pervasive technologies that can help bring forward opportunities for the rehabilitees to integrate prescribed physical exercises with mundane everyday activities. As an example, for a person undergoing rehabilitation for hip-replacement walking to a local store to shop for groceries could at the same time be an opportunity to perform exercises for balance and gait, prescribed as part of his/her rehabilitation regime. How to bring forward and present this opportunity for the rehabilitee so that they can engage with walking to the store also as an exercise towards their rehabilitation?

In this paper we continue with our line of research that explores how digital technology can be designed to bring forward opportunities for rehabilitees to turn everyday activities into exercises prescribed as part of their rehabilitation program. However, we decided to further challenge ourselves by choosing to explore the design for embodied self-monitoring in the context of motorbike riding. This is particularly challenging due to the nature of motorbike riding: The rider has to constantly engage with multiple cues, such as traffic movement, road and weather conditions, speed and capacity of the bike, etc., which constantly keep changing. How then to present data about a rider's lower-

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back posture as part of the ever-changing settings of motorbike riding?

In particular, in the ReRide design experiment presented in this paper, we draw on the notion of embodied perception [12] in the design for a 'rapid coupling' between the rider's adjustments of his/her lower-back posture and the feedback provided about this posture. We present two contributions: Firstly, ReRide presents the opening of a space for the design of digital self-monitoring technologies in support of in-situ (on the bike) adherence to rehabilitation regimens for motorbike riders suffering from serious lower-back problems. Secondly, in line with our overall research question, we position the ReRide design experiment as a challenging example of self-monitoring technology designed to bring forward opportunities for the rehabilitees to engage with physical rehabilitation as part of everyday activities.

2. BACKGROUND

2.1 Physical Rehabilitation

Works in the field of physiotherapy [9,10,11] is guided by the hypothesis that integration of physical rehabilitation exercises with mundane everyday activities will lead to better adherence and hence, in turn more successful out-of-clinic rehabilitation. The approach can be summarized as one where the physiotherapists prescribe individualized rehabilitation therapy procedures conducive for the integration with the specific everyday activities, spaces and objects of the rehabilitees. An example of this approach, observed from our interactions with professional physiotherapists, is how the rehabilitees are suggested to make use of everyday artifacts as tools for exercising, such as, filled water bottles to be used as weights, a chair to be used as support for sit-stand exercises, etc. Further, as an overall approach to increase adherence, physiotherapy literature suggests that the setting of goals is integrated with everyday activities of the rehabilitees [9].

2.2 An Interaction Design Challenge

Our previous work [1,2] reframed the physiotherapeutic working hypothesis, as a design challenge and in turn set out to explore how self-monitoring technologies can be designed to bring forward opportunities for rehabilitees to turn the performing of everyday activities into parts of a prescribed regimen for rehabilitation and/or preventive self-care ?

For example, in [2] we discuss the case of a 65-year-old hip-replacement rehabilitee utilizing brushing her teeth as an opportunity to pace and time her balance exercises. The work further speculates on if and how the toothbrush could be instrumented with sensor technologies to help the rehabilitee keep a daily record of her exercises. Another example [2] is the case of a 75-year-old woman undergoing knee rehabilitation by successfully turning her everyday activity of rocking back and forth on the swing in her garden as an opportunity to perform for knee exercises. The work presents ReSwing as an example of digital technology that offers opportunities for the rehabilitee to record her knee movements during the swinging, and utilize the data as a prop for conversation with family and friends about her rehabilitation.

2.3 Motorbike riding & Lower Back Injury

Motorbike riding, particularly in Bangalore, is physically stressful, as the rider has to commute for longer durations by sitting in uncomfortable positions required to balance the motorbike in slow moving heavy traffic [13]. A large number of people use motorcycles to commute in India. As per Bangalore Traffic Police, Bangalore had about 3.8 million two-wheelers (which includes both motorbikes and scooters) in March 2015. Motorbike riding is physically stressful. The riders have to navigate the slow, haphazardly moving traffic and bad road conditions. Such navigation requires the rider to continuously adjust the steering utilizing the upper body [6]. The constant adjustments of the upper body lead to high repetitive loading on the musculoskeletal system, particularly in lower back region [13]. Furthermore, research has shown that just maintaining the same posture for longer duration, either the lean-forward or the erect posture, while navigating the city traffic causes fatigue in lower back muscles [14].

3. METHODOLOGY

In our work we take an explorative construction oriented design research approach [8], propelled by a series of design experiments where interactive sketches are produced and put forward for in-situ experience and qualitative evaluation of this experience. The design experiments are based on the continuous active involvement of rehabilitees and therapists as domain experts on how to perform rehabilitation given the particularities of physical condition, and the physical and social settings embedding the rehabilitation process of the individual rehabilitee in question.

The exploration in this paper continues taking the construction oriented design research approach [8]. In line with choice of research methodology, the exploration is carried forward by engaging in a concrete design experiment addressing the specifics of the situation where a rehabilitee with lower back injury is made aware of, and as a result, adjusts their body posture while moving through city traffic. We built an interactive sketch using the Arduino platform. Drawing on Buxton [3], we utilized the interactive sketch, not as a prototype, but rather as a soft & hardware sketch that helps us understand and evaluate in-situ experience of ReRide. We presetned the sketch for rehabilitees as a way to experience ReRide very early in the design process. Though this experiencing was for a short duration, the interactive sketch allowed for direct bodily interactions in-situ while riding. Based on this experience, the rehabilitees offered us qualitative feedback on what it may mean to interact with the sketch. In this sense, the interactive sketch is not a prototype that is ready to be developed and productized, but a tool to inquire into the possible experiences it enables, well before finalizing the form of the idea.

4. MOTORBIKE RIDING: RAPID COUPLING

We analyzed the phenomenon of motorbike riding informed by the theory of embodied perception [12]. Svanaes stresses that human-artifact interactions are bodily phenomena, where perception is active and "involves technologies that allow the body to extend itself through external devices" [12, pg 8:17].

Our experience of motorbike riding exemplifies Svanaes' quote. While riding, the motorbike became an extension of the rider's body as they together move in and out of traffic. Our analysis further highlighted how a motorbike rider is constantly and actively engaged with a range of cues as they weave in and out of traffic. The cues were velocity and movement of vehicles around, the weather and road conditions, and the speed of their own motorcycle, etc. Furthermore the rider's active engagement with the cues involved what Svanaes terms as rapid coupling [12]. That is, the rider keeps making bodily adjustments in order to both, read the different kind of cues and respond to these cues as they move in and out of traffic. Svanaes states that to, "support embodied perception, one should consider interaction techniques

that allow for *rapid coupling* between user actions and system feedback" [12, pg. 8:26].

From our experience of riding the motorbike, we could see how the rider's body movements and the feedback offered by the cues were rapidly coupled. Based on such an understanding we decided to design for a rapid coupling between the rider's lower-back postural movements and the feedback of the movements.

5. ReRIDE: DESIGN EXPERIMENT

5.1 Design Situation

We engaged with Ashwin, a 26-year-old person rehabilitating from lower back injury due to lifestyle related repetitive stress, as a key participant throughout the design process. Ashwin suffers from L1, L2 slipped discs due to long duration of sitting at work, and long hours of motorbike riding to commute to work from home in Bangalore, India. He rides at the least for 180 minutes everyday in heavy traffic of Bangalore. His doctor has prescribed specific physiotherapy exercises, along with proper sitting postures, which includes stretching and straightening the back at regular intervals. However, it is hard for Ashwin to perform the exercises, as he does not have much time left by the time he gets home from work.

5.2 ReRide: Interactive Sketch

Figure 1: Left: Belt embedded with Flex sensor. Right: Mechanically Moving Display on the Speedometer

ReRide consists of two components, a sensing belt (see figure 1), and a microprocessor controlled mechanically moving display unit (see figure 1). The sensing belt consists of a flex sensor that is used to sense the lower back posture of the rider. The data is collected and sent by the Arduino platform to enable a servo motor that moves the display unit placed on the motorbike's speedometer based on the posture of the rider. The display unit gives full visibility of the speedometer when the rider is sitting in upright, back-straightened posture and gradually starts to change shape blocking off certain part of the speedometer if and when the rider begins to change posture and sits in a wrong position. The rider then has to adjust his back and get into the right posture in order to view the speed of the bike (see figure 1). The display moves in sync with how a rider moves their back, which we speculated will enable the rider to alter the back posture through bodily actions, in ways similar to how s/he navigates the traffic by moving their body left or right to move the direction of the motorbike.

For the sake of this experiment, we decided to place the moving display on the speedometer. Looking at the speedometer while riding is already part of a rider's repertoire of bike riding. We reasoned that placing the display as part of the rider's shifting line of sight from the road to the speedometer and back will enable the rider to engage with the self-monitoring of their back as an integral part of riding the bike.

Throughout the construction of the interactive sketch we closely worked with Ashwin. Based on Ashwin's intermittent feedback, we kept modifying the code to make display move more gradually, so that a more rapid coupling is achieved and experienced by the riders.

5.3 Experiencing the sketch

Once we were confident of the rapidity between the back posture and its display, we identified four more rehabilitees to experience the sketch. We asked the four people who were facing back injuries due to riding for long durations, to take a 30-minute ride with the ReRide sketch installed on the motorbike. One researcher rode with the rider on pillion, observing the performance (see figure 2). Following this ride, we interviewed the riders to recall and reflect on their experience. To not endanger the participants the rides happened late in the evenings, on familiar interior roads without much traffic.

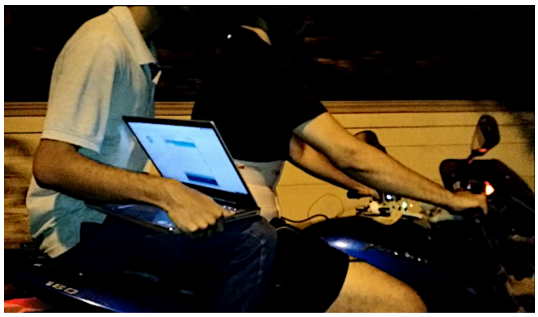

Figure 2: A rehabilitee participant experiencing the sketch, with a researcher on the pillion observing the interactions

The study has not gone through any ethical reviews, but we got participants' informed consent before the study.

5.4 Participants' Experiences

5.4.1 On Rapid Coupling

Changing the back posture, even while they were becoming aware of the back posture was the key experience of the riders. The participants corrected their ride posture as soon as their view of the speedometer got slightly covered. An interesting example was how one participant was riding in the right posture, but hit a pothole in the road, which disturbed his posture. He immediately corrected his posture back till the speedometer was visible. And he performed these actions even as he navigated the traffic around. Another participant recalled the experience conceptualizing the ReRide sketch as a metaphor for his back posture, *"What I like is that the feedback is a metaphor…the change in shape (of the sketch) is similar to crushing of my back. So it is direct relation to the amount of stress my back is in."*

5.4.2 On position and form of the display

While the participants were happy with the position of the display, they were not satisfied with its form obstructing their view of the speedometer. One participant mentioned how the display on speedometer enables him to negotiate his posture better than relying on his back pain, which is what he uses routinely. He mentioned that sometimes, particularly when he is speeding, he has to bend his back (due to the form of his 'sports' motorbike), but he does not usually know about this till he gets a back ache, at which point he straightens his back. After experiencing ReRide, he mentioned that the gradual collapsing of the display, gives him some time to remain in the bent position and get back to the right posture well before it begins to ache.

However, the participants were not enthusiastic about blocking their view of the speedometer. They mentioned how they need to keep looking at the speedometer as the police have become

stricter about speeding. They suggested that it could be better integrated with the electronic display dashboard through an animation rapidly coupled to their back posture.

5.5 Ongoing Work

Based on the feedback by the rehabilitees, we decided that while the notion of rapid coupling between the rider's back posture and its feedback seems to hold promise, the form of the display needs more work. We found that presenting the information about lower-back as a way of obstructing the rider's view of speedometer means diverting away from the core principle of designing for embodied self-monitoring. That is the form of the display did not merely present the opportunity for turning motorbike riding into a time for exercising, but actively demanded that the riders do so by correcting their posture. If not they will not get to see information about their speed.

Taking inspiration from the rehabilitees' suggestions, we decided to make the display simpler, but keeping the rapid coupling intact. We imagine the display of the feedback to be integrated with the speedometer. We are in the process of building an interactive sketch so as to enable experiencing and evaluation of the experience with the new version of ReRide. Another question we are exploring is what if information of the rider's back is presented along-with the information of the motorbike. How will such a combined display of the rider-bike influence the ride experience, particular when it comes to lower-back rehabiliation?

6. CONCLUDING REMARKS

In summary, we presented ReRide as an example of a design experiment that explored the question of how self-monitoring technology can be designed to bring forward opportunities for rehabilitees to turn their everyday activities into a part of performing prescribed exercises. Our experiences with ReRide support that designing for a rapid coupling between a rider's lower back posture and the feedback about the posture helps the rider to quickly adjust their back and also take the opportunity to perform simple lower-back exercises. Works in Human-Computer Interaction (HCI) have explored modes of providing feedback about posutre (for e.g [7]). Designing for posture correction has become an emerging area due to the importance of right posture to general wellbeing. From our experiences of sketching and experiencing ReRide, we believe that the focus on designing for a rapid-coupling between postural actions and feedback will be a fruitful direction for the works to further explore. ReRide also opens up the space of motor-bike riding as a context to explore while designing for postural correction.

Additionally, as mentioned before ReRide is a continuation of the strand of questioning explored by our previous design experiments around designing for embodied-self-monitoring [1,2]. ReRide extends the range of these examples and brings within the purview of the overarching research question, a more challenging possibility of supporting the rehabilitees to perform lower back exercises while performing the everyday activity of motorbike riding.

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8. REFERENCES

[1] Bagalkot, N. L., & Sokoler, T. 2013. Embodied-self-monitoring: Embracing the context for adherence to physical rehabilitation in the design for self-monitoring. In *2013 7th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth)* (pp. 192–199). IEEE

[2] Bagalkot, N. L., Sokoler, T., & Shaikh, R. (2012). Integrating physiotherapy with everyday life: exploring the space of possibilities through ReHandles. In *Proceedings of the Sixth International Conference on Tangible, Embedded and Embodied Interaction* (pp. 91–98). New York, NY, USA: ACM.

[3] Buxton, B. 2007. *Sketching User Experiences: Getting the Design Right and the Right Design*. Morgan Kaufmann Publishers Inc.

[4] Campbell R, et al. 2001. Why don't patients do their exercises? Understanding non-compliance with physiotherapy in patients with osteoarthritis of the knee. *J Epidemiol Commun Health*, 55:132–8.

[5] Dourish, P. 2001. *Where the Action Is: the Foundations of Embodied Interaction*. MIT Press

[6] Either, P. 2000. *Motorcycle-Rider Servomechanism Steering Theory*. Retrieved January 09, 2016, from http://papers.sae.org/2000-01-3565/

[7] Jafarinaimi, N., et al. 2005. Breakaway: An Ambient Display Designed to Change Human Behavior. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems* (pp. 1945–1948). New York, NY, USA: ACM.

[8] Koskinen, I. K. et al 2012. *Design research through practice from the lab, field, and showroom*. Morgan Kaufmann.

[9] Mastos, M., Miller, K., Eliasson, A. C., & Imms, C. 2007. Goal-Directed Training: Linking Theories of Treatment to Clinical Practice for Improved Functional Activities in Daily Life. *Clinical Rehabilitation*, *21*(1), 47–55.

[10] National whitepaper on rehabilitation, (2004) http://www.marselisborgcentret.dk/fileadmin/filer/hvidbog/hvidbog.pdf

[11] Nicholls, D.A. & Gibson, B.E. 2010. The body and physiotherapy. *Physiotherapy Theory and Practice*, 26(8), pp.497-509.

[12] Svanaes, D. 2013. Interaction Design for and with the Lived Body: Some Implications of Merleau-ponty's Phenomenology. *ACM Trans. Comput.-Hum. Interact.*, *20*(1), 8:1–8:30.

[13] Sai Praveen, V., Ray G. G., 2009. A study on Motorcycle usage and comfort in urban India. In *Proceedings 19th Triennial Congress of the IEA*, Melbourne 9 - 14 August 2015, Retrieved from http://e-journal.um.edu.my/public/article-view.php?id=1488

[14] Velagapudi, S., Balasubramanian, V., k, A., Babu, R. et al., 2010. Muscle Fatigue due to Motorcycle Riding, *SAE Technical Paper 2010-32-0100*.