Development and validation of haptic interface for deaf-blind horseback riding

M Ogrinc[1,2], I Farkhatdinov[1], R Walker[2], E Burdet[1]

[1]Department of Bioengineering, Imperial College of Science, Technology and Medicine, London SW72AZ, UNITED KINGDOM

[2]Shadow Robot Company LTD., London N11LX, UNITED KINGDOM

{*matjaz.ogrinc, i.farkhatdino , e.burdet*}*@imperial.ac.uk, rw@shadowrobot.com*

www.imperial.ac.uk/human-robotics, www.shadowrobot.com

ABSTRACT

We present a haptic interface to help blind and deaf-blind people to practice horse riding as a recreational and therapeutic activity. Horseback riding is a form of animal assisted therapy which can improve self-esteem and sensation of independence. It has been shown to benefit people with various medical conditions including autism. However, in the case of deaf-blind individuals a therapist or an interpreter must stand by at all times to communicate with the rider by touch. We developed a novel and low cost interface which enables blind and deaf-blind people to enjoy horseback riding while the instructor is observing and remotely providing cues to the rider, which improves their independence. Initial tests of the concept with an autistic deaf-blind individual received very positive feedback from the rider, his family and therapist.

1. INTRODUCTION

Animal assisted therapy (AAT) is practised to improve physical and mental health of people with various conditions. It was found that AAT has positive effects on attention deficit hyperactivity disorder (Busch et al., 2016). AAT provides significant improvements in behaviour and social interaction in humans with autism spectrum disorder (ASD). Children with autism who practiced horseback riding exhibited greater sensory seeking, sensory sensitivity, social motivation, and less inattention, distractibility, and sedentary behaviours (Bass et al., 2009).

Though horseback riding therapy may be beneficial for individuals with various conditions, some disabilities prevent the disabled to take part, as in the case of blindness and deaf-blindness. The World Health Organisation reports the world's blind population is about 39 million. Among those, it is estimated that there are around 50,000 deaf-blind individuals in USA alone (Caporusso et al., 2014). The barriers in communication and social interaction caused by deaf-blindness can lead to a number of health related difficulties, including high risk of depression, cognitive decline, developmental disorder in children and psychological distress (Dammeyer, 2014).

Hence development of novel technologies for blind and deaf-blind users is crucial as it can enable them to take part in various activities. In recent years, haptic interfaces have been developed that enable communication for the deaf-blind (Caporusso et al., 2014, Nagel et al., 2005). To our knowledge there is no low cost commercial solution for spatial navigation that provides a simple input interface and can be easily used by a deaf-blind rider and a riding instructor. Therefore, we propose a novel haptic communication system giving a deaf-blind person an ability to command a horse independently, rather than through physical guidance of the instructor. In this work we report the results of the validation trials which we believe is the world's first application of haptic technology for deaf-blind horseback riding.

2. WEARABLE INTERFACE FOR DEAF-BLIND HORSEBACK RIDING

In the conventional way of deaf-blind horse riding the rider either passively rides the horse as it is being guided by the instructor, or the rider controls the reins while the instructor communicates spatial cues by touch. Because the rider cannot experience the sense of control and independence, this conventional therapy cannot produce maximal positive therapeutic effect on the rider, who remains dependent on direct proximity of the therapist. We propose to use a simple set of vibrotactile instructions generated by a wirelessly controlled tactile actuators. Our system includes two vibration motors (tactors) worn by the rider on the upper arms which are wirelessly

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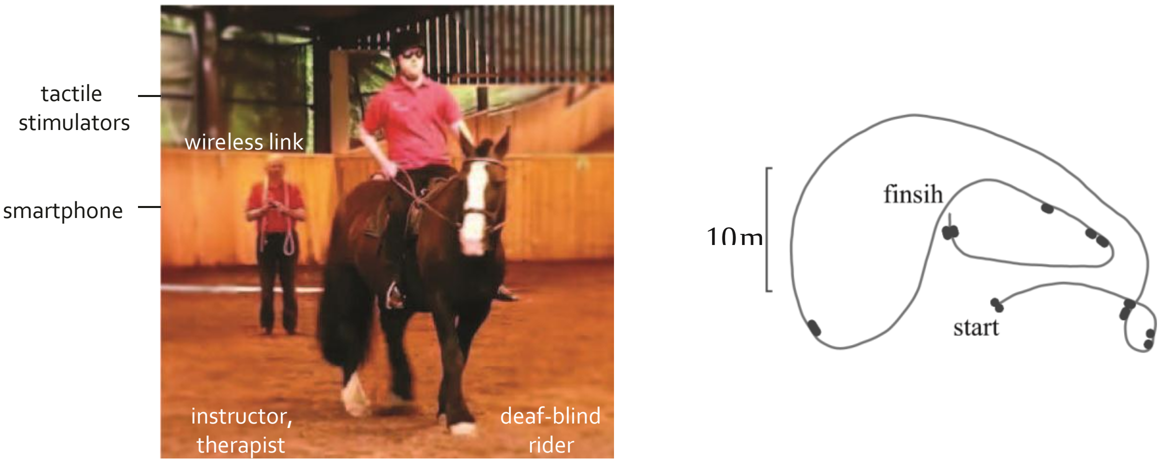
controlled by a riding instructor/therapist with the help of a custom designed Android smartphone application. While a motor is active, the rider pulls the reins in a way to direct the horse in the corresponding direction. The overall proposed concept is illustrated in Fig. 1a.



(a) (b)

Figure 1. *(a) The instructor communicates messages to the rider remotely using the proposed wireless interface. (b) Recorded trajectory of one trial. The markers on the left and right of the trajectory indicate occurrence of a vibrotactile stimulation at left and right arm respectively.*

In collaboration with the RDA (Riding for Disabled Association, UK) we defined a list of basic commands used by the instructors in horse riding with deaf-blind users. The basic commands are: “go”, “stop”, “turn left” and “turn right”. We defined a tactile stimulation combination for each of the vibration motors (left and right upper arms) in accordance to selected basic commands. A short simultaneous vibration (1 s) of both actuators instructs the rider to command the horse forward (command “go” to start the movement). A long simultaneous vibration (2 s) of both actuators stands for “stop”. Vibration on either arm suggests a turn in the respective direction.

The interface was composed of inexpensive, simple and robust components. Two vibration motors (model 307-100, Precision Microdrives, UK) were selected to display haptic instructions to a deaf-blind rider. The motors were powered by a custom-designed control module, which was small enough to be carried in a rider’s pocket. The control module contained a microcontroller and wireless communication electronics. The module connected to a host mobile device via Bluetooth communication protocol. The device was powered by a 3.7 V LiPO rechargeable battery. The proposed interface is low cost: excluding the cost of an Android mobile device, the total cost of the prototype is under £50. An Android OS application has been developed for controlling the interface.

3. A FEASIBILITY STUDY ON DEAF-BLIND RIDING

3.1 Subjects and experimental protocol

We tested our tactile guidance system in real horseback riding in collaboration with the RDA. An autistic deaf-blind rider (male, age 31, completely deaf and blind since childhood) participated in the study where we experimentally evaluated the performance of riding with the proposed tactile interface. He was using the interface for 10 months prior the present study took place. The tests were carried out in a riding arena. The subject wore our tactile interface which was remotely controlled via a smart phone by a professional riding coach. A deaf-blind tactile language interpreter facilitated communication with the rider. An XSens (Enschede, Netherlands) wireless inertial measurements units (IMU) MTw module was attached to the subject’s torso to track their motion (sampling rate 75 Hz) which enabled us to reconstruct their trajectories. Two additional IMUs were attached to the subjects’ upper arms on top of the vibration actuators to detect the occurrence of vibrations and thus synchronize the stimulation and motion capture data. In the riding tests the subject was asked to follow the random sets of commands given by the instructor. All required safety regulations were observed during the tests and permission from the family of the blind-deaf rider was obtained.

3.2 Results

We reconstructed the movement trajectories based on the IMU measurements. Fig. 1b shows one trajectory. The overall feedback from the subject and the therapist was very positive. Their comments indicated that the subject has been enjoying the riding sessions with the tactile interface more than the conventional one, as he felt to directly control the horse. The subject felt confident and safe during horse riding with the help of the tactile interface.

However, we report that, some commands to change the direction of riding were not executed. There could be several explanations for this: 1) the subject had issues interpreting the stimuli either due to troubles in perception or 2) lack of attention, 3) the subject pulled the reins accordingly but the horse did not respond to the command. Lack of attention is often associated with attention deficit hyperactivity disorder (ADHD) typical for autistic condition (Burack et al., 1997). The rider however successfully carried out all commands to stop the horse, which is crucial to guarantee safety during horseback riding therapy. A possible explanation for this might be that the stop cue is long (lasts 2 s) which captures the attention of the rider.

4. CONCLUSION

We presented a novel haptic interface which enables deaf-blind people to practice horse riding. The outcome of the tests was very positive. The approach has been well accepted by the rider, his family and the therapist. As reported by his carers, the rider has been looking forward to each weekly riding session. In this paper we analysed the perception and effectiveness of the proposed interface that showed promising results. In the future we plan to take a closer look at the therapeutic effects of the horseback riding with respect to the subject's autism by means of standard assessment techniques used in the field, namely questionnaires. We also plan to improve the ergonomics of the interface and introduce it to a larger number of users.

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5. REFERENCES

Bass, M. M., Duchowny, C. A. & Llabre, M. M. (2009), The effect of therapeutic horseback riding on social functioning in children with autism, *Journal of Autism and Developmental Disorders* **39**(9), 1261–1267.

Burack, J., Enns, J., Stauder, J., Mottron, L. & Randolph, B. (1997), Attention and autism: Behavioral and electrophysiological evidence, *Handbook of Autism and Pervasive Developmental Disorders* **2**, 226–247.

Busch, C., Tucha, L., Talarovicova, A., Fuermaier, A. B., Lewis-Evans, B. & Tucha, O. (2016), Animal assisted interventions for children with attention deficit/hyperactivity disorder a theoretical review and consideration of future research directions, *Psychological Reports* **118**(1), 292–331.

Caporusso, N., Trizio, M. & Perrone, G. (2014), Pervasive assistive technology for the deaf-blind need, emergency and assistance through the sense of touch, *in* A. Holzinger, M. Ziefle & C. Rcker, eds, Pervasive Health, Human Computer Interaction Series, Springer London, pp. 289–316.

Dammeyer, J. (2014), Deafblindness: A review of the literature, *Scandinavian Journal of Public Health*.

Nagel, S. K., Carl, C., Kringe, T., Märtin, R. & König, P. (2005), Beyond sensory substitution – learning the sixth sense, *Journal of Neural Engineering* **2**(4), R13.