Interaction Gestures for a Wearable Device Defined by Visually Impaired Children

Charlotte Magnusson
Héctor Caltenco
Certec, Lund University
Box 118, 221 00 Lund, Sweden
Charlotte@certec.lth.se
hector@certec.lth.se

Elena Cocchi
Instituto David Chiossone
Corso Armellini 11,
16100 Genoa, Italy
cocchi@chiossone.it

Sara Finocchietti
Monica Gori
U-VIP, Italian Institute of Technology
Via Morego 30,
16163 Genoa, Italy
sara.finocchietti@iit.it
monica.gori@iit.it

Lope Ben Porquis
Gabriel Baud-Bovy
RBCS, Italian Institute of Technology
Via Morego 30,
16163 Genoa, Italy
lope.porquis@iit.it
gabriel.baud-bovy@iit.it

NordiCHI '16, October 23-27, 2016, Gothenburg, Sweden
 ISBN 978-1-4503-4763-1/16/10…$15.00
DOI: http://dx.doi.org/10.1145/2971485.2996752

Abstract
This paper reports results from two workshops organized with children with visual impairments ranging from blindness to low vision. The aim of the workshops was to suggest gestures for the interaction with a small wearable audio-bracelet. Results show a preference for mechanical buttons and touch-based gestures on the device (mainly tapping and sliding), while only one tentative suggestion is made for a gesture made with the device (shaking).

Author Keywords
Micro gestures; wearables; visual impairment; co-design.

ACM Classification Keywords
H.5.2 [User Interfaces]: Interaction styles; H.5.2 [User Interfaces]: User-centered design; K.4.2 [Social Issues]: Assistive technologies for pesons with disabilities.

Introduction
This paper presents work done in the framework of the ABBI (Audio Bracelet for Blind Interaction) EU project. ABBI is a project aimed at developing new wearable technology (an audio bracelet) to improve sensory-

Figure 1. ABBI bracelet together with a mobile device. By default, the ABBI is quiet when it is stationary, and only makes sounds when it is moved.

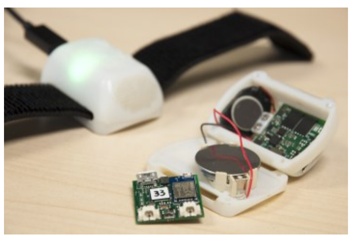

Figure 2. ABBI hardware, circuit board, battery and speaker inside plastic enclosure.

motor rehabilitation for children with visual impairments. Visuo-motor feedback is fundamental to calibrate our body and space perception [5] and it has been verified that hearing can be used to substitute vision in this process [2]. The ABBI bracelet supports this process by allowing a person, who is unable to see the location of their own body, to listen to it instead [4]. The ABBI bracelet can also be used in groups to locate the position and movement of other persons, which allows blind children to interact and play games together [8].

In its current design, the standard modality of use of the ABBI bracelet is very simple: it plays a sound when it is moving and keeps quiet when it is still. The device does not include any button or interface to change its settings or to start or stop a sound for example. While a smartphone app allows for extensive control of the device, observations during earlier studies [8] indicated that it would be helpful if parameters like volume and sound could be changed directly from the device itself. Recent studies suggested that user defined gestures are easier to remember [12], and thus we wanted to explore the ABBI gesture design space together with our end users – children with visual impairments. In order to do so, we organized two co-design workshops at the Chiossone Institute in Genoa, Italy. This present paper presents initial findings from these workshops.

Related work

Smartphone and tablets are the most common type of wearable device used by blind persons, who use the touch screen and together with voice over feedback to control them [11]. Wearables can also take the form of head-worn displays, glasses (recently Google glass), smart textiles, shoes, armbands, jewelry, etc. [9] – basically anything interactive somehow worn on the body. While not specifically designed for persons with visual impairments, such devices, with their potential for eyes-free interaction, hold promise also for persons with visual impairments [18]. Several studies have investigated the design of sound-producing wearable devices with sighted children. For example, the bracelet presented in [1] is designed to support playing by enhancing RFID tagged objects to play sounds and show lights. Sounds are also used in “SoundTag” [14] where interactive tags were designed to be worn during the game “tag”. Tagaboo [6] uses a specially designed glove that can respond (by playing sounds) to tags placed in pockets or similar. Few studies focus on the control gestural control of wearable devices by visually impaired persons. Some examples are [15], where co-design workshops were perforemed with blind adults to investigate the usefulness of the wearables for the identification of landmarks, and [10], where sensory substitution is used for blind users to play video games using whole body gestures.

The ABBI bracelet

The ABBI bracelet is based on a small custom designed circuit (24 x 25 mm), which includes a powerful processor (ARM Cortex M3), an 9-axis Inertial Measurement Unit (IMU), 16 MB Flash memory, a Smart Bluetooth module and a sound amplifier. The circuit fits with the battery (120 mA) and speaker in a robust enclosure (55 x 35 x 25 mm), which can be fixed on a wrist band (Figure 2).

The difference between the above mentioned designs and ABBI lies both in the focus and simple design. In particular, the ABBI device has been conceived from the onset to be used by blind children possibly as

Gender	Age	Vision
F	12	L&S
F	12	none
F	14	L&S
F	15	L&S
F	17	L&S

Table 1. Workshop participants, blind children (L&S: light and shadows)

Gender	Age	Vision
M	15	1/20
M	8	1/10
M	11	1/20
F	10	1/10
F	13	1/10
F	15	1/50

Table 2. Workshop participants, children with low vision

young as 1-year-old. While the device is highly configurable, its design and modality of use was kept deliberately very simple. A smartphone app can be used to select and configure a sound, which can be synthetic or recorded, according to the preference of the user [7]. Then, during the rehabilitation, the sound is triggered by the movement of the device without any other user intervention [4]. The experience gained during the first year of the project and observations obtained during earlier studies [8] suggested that it might be helpful to have some additional control of the device such as the volume of the sound without using the smartphone. For this reason, a hardware button was added to the new version of the ABBI device.

Workshops

Two co-design workshops of approximately 30 minutes were organized at the Chiossone institute in the early spring of 2016. The workshop participants are listed in **Table 1** and **Table 2**. All the participants were familiar with the ABBI and had used it in previous studies. The workshops were video recorded, transcribed and translated to English.

At the workshop the participants had access to ABBI devices. One being a new version which also had a small button. This ABBI was sent around the table so that all the children could feel it. The children were told that we would like their suggestions for gestures for the different functions we would be presenting. Additionally, we explained that a "gesture" could be anything from pressing the button on the device, shaking, moving or tilting the device, tapping on the device, or manipulating it in some other way. We then explained the functions one by one and asked the participants for ideas for each presented function. The functions investigated were *mute/unmute*, *change the volume*, *change the sound*, *adjust the sensitivity* and *change between pre-programmed settings*. The questions about ideas for each function were asked "in the open" which lead to discussions between the participants which are hard to quantify, therefore not all observations below are quantified.

Results and discussion

The children at both workshops came up with several suggestions of gestures for functions already controlled by the ABBI smartphone app, such as mute/unmute, change volume and sound functions. Other functions not available yet in the ABBI app, such as the sensitivity (how quickly the ABBI responds to movement) and the saved settings turned out to be more abstract and the children found these more difficult. All suggestions made are listed in **Table 3**.

In general, most of the children preferred making gestures *on* the device (tapping and sliding) to making gestures *with* the device (shaking, moving, tilting). This was a conscious decision in the first group where one child commented that bigger gestures could cause accidental activation: "*if the movement is too big it will be difficult to be used in everyday life as it could make it sound when we don't want it*" and that control gestures are different from the movements you make during rehabilitation: "*but then it should be a movement that we don't do all the time*". In the second group there was no discussion about this – in fact the discussion turned almost immediately to hardware buttons/wheels. Still, this group also suggested tapping and sliding gestures for sound changes. One participant did suggested that shaking could be used, although the discussion immediately moved on from there.

Figure 3. Child demonstrating a gesture interaction.

Figure 4. Test leader and test aids guiding the children hands to demonstrate a gesture.

	Blind		Low Vision	
	Buttons / wheel	**Surface sensor**	**Buttons / wheel**	**Surface sensor**
Mute/un mute	Button click	Double tap	use scroll wheel	-
Increase volume	Tap twice	Slide up	Scroll wheel down	Slide right
Decrease volume	Tap once	Slide down	Scroll wheel up	Slide left
Next sound	Scroll wheel CW	Slide right	Right button, handle to right, Shake device	Tap, then slide right
Previous sound	Scroll wheel CCW	Slide left	Left button, handle to left	Tap, then slide left
Sensitiv. Up	In app	Slide rotation CW	Maybe other buttons?	In app
Sensitiv. Down	In app	Slide rotation CCW	Maybe other buttons?	In app
Next setting	In app	In app	Press button multiple times	In app
Previous setting	In app	In app	-	In app

Table 3. Suggested gestures for the different functions from both workshop groups, blind (**Table 1**) and low vision (**Table 2**). Some gestures would require buttons and hardware scroll-wheels to be added to ABBI. Others would require a touch-sensing matrix to be placed at ABBI's surface.

The suggestions, from the second group in particular, makes it quite clear that hardware buttons, wheels or handles are thought to be a very good way to interact – this is not surprising, since the children have visual impairments and this kind of interaction allows you to clearly feel what is happening.

There is a clear difference between the groups, where the first group provide more gesture ideas while the second group quickly zooms in on adding additional hardware. Our interpretation is that this has less to do with the visual ability of the children involved, and more to do with age and mobile phone experience (some of the younger children did not use a smartphone). In fact, one of the children of the Blind group explicitly refer to the smartphone when discussing rotational gestures: "*we could use the rotatory movement as in the smartphone*". Also, children with Low Vision who use a smartphone use the remaining sight as much as possible and do not use accessibility functions, such as Talkback [8].

An observation made during the test was that while it was quite easy to discuss and demonstrate gestures (Figure 3), it turned out to be quite hard to share them with the whole group. When needed, the test leader would demonstrate a gesture to all children in the group (one after the other) by guiding their hands (Figure 4). The children were still quite good at explaining what they meant, but it is possible that this also skewed the discussion in favor of gestures that were easy to explain. Given that the gestures implemented should be both easy to explain as well as easy to remember, this is not necessarily something negative – but it is a bias one needs to be aware of.

Another observation was that most of the children came up with solutions that were not "in the brief" by adding new hardware. It is always a concern at these one guides the participants to give the results one wants, but we interpret this fact to mean that our participants did not feel too tightly bound by the instructions.

The results indicate that the *sensitivity* and *change of settings* functionality fit better in the smartphone app, while the *mute/unmute*, *volume change* and *sound change* could be made on the device. As one child commented "*And the sensitivity is a feature that you want to change at the start of the rehab session and you don't change it all the time*". This preference may be biased by the fact that the current ABBI allows for volume and sound changes, while changing the sensitivity and switching between saved settings were new functionality. The younger children found particularly the concept of saved settings difficult to grasp: *"I didn't understand much as I don't use the phone"*. Our interpretation is that the recommendation to use the app to change the sensitivity is because all the children have experienced how much you need to move the ABBI in order to activate it, while it is possible that switching between saved settings on the ABBI may still turn out useful and suitable for gestures.

For a device without touch sensitivity (only using the built in accelerometer) we get the following interaction suggestions: button press, tapping (twice to increase, once to decrease) and possibly also shaking the device. With touch sensitivity sliding gestures up/down, right/left and rotational gestures would also be possible. A potential extension of the tapping could be to tap at different sides of the device (causing the device to move in different directions) – this was not suggested in the workshops, but is one possible way to widen the scope of the tapping interactions.

Conclusion

This paper reports on a design workshop performed with children with visual impairments. We see the contribution of this work as twofold. The first contribution is actually to serve as a practical example of how to involve children with visual impairments in design. While there are many studies where sighted children participate in co-design activities [3,16,17], visually impaired children are more often seen as testers or technology for visual impaired children is tested in sighted people [13]. The second contribution is to provide us with suggestions for interaction. We note that hardware such as buttons and wheels are popular, but also that there is a preference for gestures made *on* the device such as tapping and sliding over making gestures *with* the device (the only suggested gesture with the device is shaking).

Unless one explicitly wants to favor gestures that are easy to explain by voice, the observed difficulties with gesture sharing is something that needs to be addressed in future similar work. Placing participants within easy reach of each other is one solution – but it is an interesting design challenge to find more general ways to share haptic/kinesthetic information when participants are further away. In contrast with video (which can be seen by many sighted persons at the same time), we are still waiting for the development of "hapteo".

In future work we plan to investigate the possibility of adding hardware wheel, besides the hardware button, and implement gesture-based interaction on the ABBI device to control some ABBI functions directly from the device itself.

Acknowledgements

We thank the EU for supporting the ABBI project. We also thank all the children and trainers involved in the activities.

References

[1] Amores, J., Benavides, X., Boldu, R., and Maes, P. Exploring the Design of a Wearable Device to Turn Everyday Objects into Playful Experiences. *Extended Abstracts of the ACM CHI'15 Conference on Human Factors in Computing Systems 2*, (2015), 2145–2150.

[2] Cappagli, G., Baud-Bovy, G., Sandini, G., and Gori, M. Auditory-motor training improves audio spatial localization. *9th Forum of Neuroscience*, (2014).

[3] Druin, A. The role of children in the design of new technology. *Behaviour & Information Technology 21*, 1 (2002), 1–25.

[4] Finocchietti, S., Cappagli, G., Porquis, L. Ben, Baud-Bovy, G., Cocchi, E., and Gori, M. Evaluation of the Audio Bracelet for Blind Interaction for improving mobility and spatial cognition in early blind children - A pilot study. *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*, (2015), 7998–8001.

[5] Gori, M., Sandini, G., Martinoli, C., and Burr, D. Poor Haptic Orientation Discrimination in Nonsighted Children May Reflect Disruption of Cross-Sensory Calibration. *Current Biology 20*, 3 (2010), 223–225.

[6] Konkel, M., Leung, V., Ullmer, B., and Hu, C. Tagaboo: A collaborative children's game based upon wearable RFID technology. *Personal and Ubiquitous Computing 8*, 5 (2004), 382–384.

[7] Magnusson, C., Caltenco, H., Finocchietti, S., Cappagli, G., Wilson, G., and Gori, M. What Do You Like? Early Design Explorations of Sound and Haptic Preferences. *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct - MobileHCI '15*, (2015), 766–773.

[8] Magnusson, C., Rydeman, B., Finocchietti, S., et al. Co-located games created by children with visual impairments. *MobileHCI '15 Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct*, (2015), 1157–1162.

[9] Mann, S. Wearable Computing. *The Encyclopedia of Human-Computer Interaction, 2nd Ed.*, 2014.

[10] Morelli, T. and Folmer, E. Real-time sensory substitution to enable players who are blind to play video games using whole body gestures. *Entertainment Computing 5*, 1 (2014), 83–90.

[11] Morris, J., Mueller, J., Jones, M., and Lippencott, B. Wireless technology use and disability: Results from a national survey. (2014).

[12] Nacenta, M.A., Kamber, Y., Qiang, Y., and Kristensson, P.O. Memorability of Pre-designed & User-defined Gesture Sets. *CHI '13 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, (2013), 1099–1108.

[13] Segond, H. A Proposed Tactile Vision-substitution System for Infants Who Are Blind Tested on Sighted Infants. *Journal of Visual Impairment Blindness 101*, 1 (2007), 32–43.

[14] Ueoka, R., Kobayashi, H., and Hirose, M. SoundTag: RFID based wearable computer play tool for children. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, (2009), 36–47.

[15] Ugulino, W. and Fuks, H. Landmark Identification with Wearables for Supporting Spatial Awareness by Blind Persons. *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, ACM (2015), 63–74.

[16] Walsh, G., Druin, a, Guha, M., et al. Layered elaboration: a new technique for co-design with children. *Conference on Human Factors in Computing Systems*, (2010), 1237–1240.

[17] Xie, B., Druin, A., Fails, J., et al. Connecting generations: developing co-design methods for older adults and children. *Behaviour & Information Technology 31*, 4 (2012), 413–423.

[18] Ye, H., Malu, M., Oh, U., and Findlater, L. Current and Future Mobile and Wearable Device Use by People With Visual Impairments. *Chi 2014*, (2014), 3123–3132.