What Do You Like? Early Design Explorations of Sound and Haptic Preferences

Charlotte Magnusson
Héctor Caltenco
Department of Design Sciences
Lund University
Sweden
charlotte@certec.lth.se
hector.caltenco@certec.lth.se

Sara Finocchietti
Giulia Cappagli
Italian Institute of Technology
Italy
sara.finocchietti@iit.it
giulia.cappagli@iit.it

Graham Wilson
Glasgow Interactive Systems Group
School of Computing Science
University of Glasgow
UK
graham.wilson@glasgow.ac.uk

Monica Gori
Italian Institute of Technology
Italy
monica.gori@iit.it

MobileHCI '15 Adjunct, August 24-27, 2015, Copenhagen, Denmark
ACM 978-1-4503-3653-6/15/08.
http://dx.doi.org/10.1145/2786567.2793699

Abstract
This study is done within the framework of a project aimed at developing a wearable device (a bracelet) intended to support sensory motor rehabilitation of children with visual impairments. We present an exploratory study of aesthetic/hedonistic preferences for sounds and touch experiences among visually impaired children. The work is done in a participatory setting, and we have used mixed methods (questionnaires, workshop and field trial using a mobile location based app for story creation) in order to get a more complete initial picture of how enjoyable training devices should be designed for our target users.

Author Keywords
Preferences; visually impaired; sound; audio; tactile; haptic; wearable

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

Introduction
This paper presents work done in the framework of the ABBI EU project. ABBI is aimed at developing new wearable technology (an audio bracelet) to improve sensory-motor rehabilitation for children with visual

Figure 1. ABBI bracelet (bottom) together with mobile device.

impairments. Visuo-motor feedback is fundamental to calibrate our body and space perception [1] and it has been verified that hearing can be used to substitute vision in this process [2]. Since we aim at long-term use in rehabilitation of sounds and touch experiences and want our users to keep using our technology, we need to produce designs that are pleasant - or at least interesting enough. Thus, we decided to start our design work by investigating the hedonic/aesthetic preferences of our prospective users. A specific challenge for the participatory work was that the end users are visually impaired. Co-design activities with children like the ones described in [3] are not uncommon, but typically make use of visual materials like drawings, images, screen displays etc. The same is true for the common lo-fi prototyping materials pen and paper. Thus, we had to put special effort into designing activities and materials to work non-visually.

Related work

Studies of sounds/haptics involving persons with visual impairments tend to target cognitive aspects or be usability tests of multimodal systems. We have not found any studies on basic aesthetic preferences. In [4] sound designs for selected scenarios are investigated, but this work is an example of inclusive design, not a study of basic sound preferences. For sighted persons it is known that for simple synthetic sounds, high frequencies and volumes are generally considered less pleasant. It is also known that the perceived source of a sound may affect the experienced pleasantness - vomiting is one example [5]. There are very few studies of haptic/tactile preferences – a recent study of texture preferences [6] shows that rough textures are generally perceived as less pleasant. Thus, although studies on emotional responses to sounds and to some extent touch experiences have been made for "people in general", similar studies targeted at visually impaired persons are largely missing. Given that differences have been found between sighted persons and persons with visual impairments with regards to sound mappings [7], and that trainers and teachers had informally pointed out to us that tactile/haptic preferences can be quite different for children with visual impairments (scientific studies on this are missing), we found it important to explore the initial preferences of our intended user group – children with visual impairments.

Method

Preferences may vary depending on context (eg. a scary sound may be acceptable in a movie, but disliked when you hear it in real life). This led us to use a mixed set of methods combining questionnaires and rating of sounds ("is this sound pleasant or unpleasant") with more creative activities involving creating interesting "toys" and location based sound-stories. The rating of sounds and the creation of interesting "toys" were performed at three workshops at the Chiossone Institute in Italy (one workshop with habilitation personnel and two workshops with children). The creation of location based sound-stories took place at an invited activity at a summer camp for visually impaired children in Sweden.

This method mix included both activities intended to capture direct preferences – your immediate reaction in terms of pleasure/dislike upon hearing a sound - but also more activity related preferences: how do you react to sounds and tactile experiences when these are assigned to a toy, and what kind of sounds would you like when telling stories (storytelling may be a part of playing with toys)?

Questionnaires
To get initial information on sound preferences – but also to get the children to start thinking about their sound preferences – a short questionnaire was distributed and digitally and answered before the three workshops in Italy. The questionnaire was answered by 16 children between 8 and 16 (9 girls, 7 boys) and contained the following questions:

- Please describe shortly a sound you think is pleasant to listen to – and if possible add a comment on why you like it.
- Please describe shortly a sound you think is unpleasant to listen to – and if possible add a comment on why you don't like it.
- Please describe shortly a material you think feels pleasant to touch – and if possible add a comment on why you like it.
- Please describe shortly a material you think feels unpleasant to touch – and if possible add a comment on why you don't like it.

Sound and touch workshops, Italy
Three workshops were performed at the Chiossone Institute, Italy. The first pilot workshop involved 10 staff members of the ABBI project, the second was a workshop with 9 blind children and the third workshop with 8 children with low vision. At these workshops we explored what kind of sounds and materials the children thought were pleasant or unpleasant. The workshops were designed with two exercises:

1. Exercise 1: a focus group type exercise where 71 different sounds (32 recorded natural and 39 synthetic) were played and the children could raise their hands if they liked/didn't like them (or do nothing if they felt neutral). Hand raising was selected since it allowed the children to answer simultaneously without influencing each other too much (since the children had visual impairments, their ability to see what the others were doing was limited).
2. Exercise 2: a design exercise where the children were asked to combine a tactile object and a sound to make a nice, cool or interesting "toy". Children could associate one of the 20 sounds stored in an NFC tag and play it back by touching the material with a smart phone, or by vocalizing their own sounds.

After the pilot workshop it was decided to change the order of the sounds in exercise 1 so that the recorded natural (potentially more interesting) sounds were played first.

MATERIALS
In our study we aimed at getting initial feedback on qualities of different natural and synthetic sounds. We did not want to directly target music, since music is subject to strong personal tastes, and preferences depend on performance as well as content.

To span the space of natural sounds we relied on the classification made by the futurist Luigi Russolo who classified "noise-sound" into six groups [8]. The potential number of sounds is more or less infinite, and we tried to come up with a limited set that both covered these categories and where the sounds were

Figure 2. Tactile materials used for the workshops

Figure 3. Near Field Communication **(**NFC) tags

not too similar. As extra input we used the answers to the questionnaire to make sure we didn't leave out sounds mentioned by the children (this added birds, a phone and a grandfather clock to the set). The final sound set was:

1. **roar**: monster roar, explosion
2. **whistling**: hydraulic hammer, sonar-ping, whistling, phone
3. **whispers**: bubbling, car, hoover, rocket, water poring, waves, whispering, wind
4. **buzzing**: crackling, creaking door, footsteps, mosquite buzzing, scraping
5. **beat**: drums, metal, hitting wood, hitting stones, grandfather clock
6. **voice**: dog howl, elephant, horse neigh, laugh, scream, sheep, sobbing, birds

The smaller number of sounds in the bang/roar category was motivated by many bang/roar type sounds sounding quite similar (they were also hard to play back well on the limited speaker capacity of a mobile phone). The sounds for different categories were mixed at playback but we decided to use the same order for all workshop groups (few groups and many sounds made balancing hard).

For the synthetic sounds we decided to rely on a classification based on pitch, loudness and timbre [9]. Since loudness (volume) should be possible to control for the user, we excluded that parameter. For ABBI some sounds may be played during extended periods of time, and considering that sounds which are well liked when they are short, may potentially be annoying when they are played for longer durations, we added duration as a parameter. Thus we used the following parameters for the synthetic sounds: *Pitch*: high, low and wide (noise); *Timbre*: clear/bright/sharp vs. fuzzy/dull/ round; *Duration* (short, long and if possible repeated)

The synthetic sounds also included sine and square waveforms and white noise. Each sound (except white noise) was available in two pitches – one lower and one higher, except for the noise sound that had a wide range of frequencies. Continuous sounds were available in short (0.3 s) and long (8 s) versions. Sounds with an envelope were available in single and repeated versions. In total 39 sounds were included in the set.

The materials for the workshops were selected to vary in texture, friction and hardness ([6] investigated only texture). Shape was not explicitly included as a parameter – the children were asked to consider the material, not the shape. Figure 2 shows the objects used grouped according to hardness (hard in the top image, and soft in the bottom).

For the workshop, the children were asked to associate one material they liked to a specific sound and action. To associate sounds tangibly to a physical material, we used NFC tags to store sound filenames that can be played by touching the tagged objects with mobile devices. The sounds that were recorded in the NFC tags were a selection of 12 natural and 8 synthetic sounds:

1. **bea**t: smash-wood, drums
2. **buzzing:** creaking door, mosquito buzzing
3. **roar:** monster roar, short explosion
4. **voice:** horse-neigh, sobbing
5. **whispers:** waves, bubbling
6. **whistling:** sonar-ping, whistling/birds

Figure 4. Following a location based story trail (image from a test of the TimeMachine tourist app developed in the HaptiMap project)

7. **high pitch/short:** short high bell, short high sine
8. **high pitch/long:** long sine
9. **low pitch/short:** low short sine, low short synth sound
10. **low pitch/long:** low square
11. **wide/short:** short noise
12. **wide/long:** long noise

Sound-story workshop in Sweden

At this workshop we used a location based app developed within another project (UUT) to allow visually impaired persons to create and experience outdoor story-trails. We had been invited by the persons arranging a summer camp for children with visual impairments to arrange a fun location based activity, and decided this could also be a good opportunity to gather more information about sound preferences in a more realistic situation. In order to do so, the natural sounds from the sound and touch workshops were added to the app, so that for each story GPS point location one pre-recorded natural sound could be assigned/played alone or together with a voice recording. A few synthetic sounds were also added: the long square and sine tones, the low synth, white noise, piano and high and low ping. The selection focused on timbre, and included both clean/bright sounds and muffled/noisy ones. The app was an android app, which was made available on SONY xperia smartphones brought by the researcher. If needed the screen reader was activated. The app used at the activity had only a single trail.

The activity was designed as group work in a series of one hour slots where 8 children divided into 3-4 groups of 2-3 persons would first get a joint short introduction and try an example trail (the groups in the first time slot tried an example created by the researcher while following groups tried a part of one of the trails created by the groups in the previous time slot). After this they created their own trail, tested it, and if there was time swapped phones with another group and tried theirs. The researcher together with persons working at the camp were available as support in case of technical problems. Due to the nature of the activity (a summer camp) the activity could not be tightly controlled and we were unable to film/record or gather personal data. The only material saved was the created trails, which were copied and stored after each slot.

Results, Questionnaire

As can be expected there was quite a bit of variation in the responses to the questionnaires. Sounds can be pleasant in themselves ("I like the sound of the guitar and I prefer low frequency sounds"), but also because they are associated with something nice ("I like the sound of the telephone because it means that someone comes."). Musical sounds, nature sounds (birds, waves, neigh) and rhythmical sounds seem generally popular. Loud, sharp or sudden sounds are generally unpopular.

For the touch experiences soft or furry things are popular, but also many hard materials (wood, metal, sea stones, cardboard/paper, joystick). Unpopular materials are sharp, too cold/hot or rough (in agreement with [6]) - materials that can hurt you - but also sticky, runny or clay like materials (play dough, finger paint, glue, soil, puddle). Also rubbery things like balloons or rubber toys as well as toilet paper can be experienced unpleasant. Just as vision can be influenced by touch and touch experiences can be

Figure 5: Exploring tactile detail

influenced by vision [10], touch experiences may also be influenced by the sense of smell – a flower is nice to touch because of the smell, while eggs may be unpleasant because they are thought to smell bad.

The comments on touch show that children with visual impairments may have quite different material preferences compared to children who can see the materials – many standard toy or "fun" materials such as finger paint, play dough, balloons, rubber toys that potentially rely heavily on their visual properties for their "fun" status, are on the unpleasant list. These kinds of materials are more undefined (soft/sticky/runny) and the result of this study confirms the informal observations that these kinds of materials are indeed less popular among persons with visual impairments.

Results, sound and touch workshops

As with the questionnaires, the individual preferences expressed in the hand raising exercise varied widely. The most pleasant individual natural sounds were sea waves (liked by 14 of the 17 children), bubbling (liked by 14) and birds (liked by 13). The least pleasant were the scraping sound (liked by 7), mosquito buzzing (liked by 5), hoover (liked by 5), creaking door (liked by 4) and scream (liked by 3). Among the synthetic sounds the most pleasant one was the high pitch rhythmical drops sound (repeated and short, liked by 15), while the most unpleasant were the "clean sounds" (pure sine and square tones), especially the long duration ones.

The tangible representation of the sounds used in the second exercise was seen to work well and allowed participants to physically manipulate and select different sounds (moderator support was provided to keep the apps on the phones working). With tangible objects it was possible to sort sounds in piles and also to revisit and refine selections. Additionally having tangible sound objects allowed the children to physically associate a sound with a material – a design which appeared well suited to the participating children. The selections are summarized in tables 1 and 2.

Group	Material	Sound
1	Soft rubbery toy	Ping/Beep
2	Soft rubbery toy	Waves
	Fur	Birds
3	Hard ball	Explosion
4	Soft rubbery toy	Ping

Table 1. Summary of selections, children with low vision

Group	Material	Sound
1	Fur	Birds
2	Felt clad wooden block	Birds
3	Hard ball	Phone
4	Fur, soft rubbery toy	Waves

Table 2. Summary of selections, blind children

Although the number of participants is limited, we note that the soft rubbery toys were more popular in the group with children with low vision. In the blind group the fur and the hard materials were mostly preferred – although one person in the group with children with low vision also selected a hard material. The soft rubbery toys had a lot of small details – something that was seen to encourage haptic exploration and appeared to make them more interesting to touch for some participants (two of the boys – one in each group -

SOUNDS CAN:
Facilitate story creation (if the technology supports simple selection of existing sounds)

Be a sound effect/illustration together with speech, enhancing what is said

Be a story element on its own (a scream may not need any additional explanation)

Be a sound effect creating an ambience or sense of a place (e.g. waves, birds) without any additional speech

Provide creative inspiration – listening to different sounds can trigger your imagination

enjoyed this object and kept manipulating the toy for a long time).

In general the natural sounds (birds, waves) were popular also for this more creative exercise but one person liked more drastic sounds and used a bang/explosion sound. The choice of sound was associative in several cases – a crocodile lives in the water, the material feels like grassland which implies birds, material and sound reminds of holiday, while others seemed more to be notifications (ping/beep) or just "nice". It should be noted that not all sounds selected are pleasant – we also see a need for more drastic sounds like bangs or explosions.

Results, sound story workshop

26 of the 40 children between 7 and 16 attending the summer camp decided to participate in the activity. In total 15 trails were created and saved. Three of these were made by the same person, while all others were made by different persons. Some stories contained only sounds, some had a combination of sounds and spoken narrative and some used only the default "ping" sound and focused on the spoken narrative. Of the 15 trails 3 were pure sound narratives without any speech, 6 were some sort of adventure or action story, one was a treasure hunt (find a missing person), 2 were ghost stories and 3 were some sort of fictional or real story about the locations at the camp (a detailed analysis of the stories and the storytelling lies outside the scope of this paper). The average number of trail points was 6 (range: 3-13, standard deviation 3).

Out of the 41 sounds 25 were used at some point. The most popular sound after the default notification sound (35 uses) was the explosion (8 uses) followed by footsteps (7 uses), scream (6 uses), car (4 uses), sobbing (4 uses), waves (3 uses) and birds (3 uses). This shows that when you are creating stories drastic and unpleasant sounds can play an important role – something which is also supported by the earlier workshop results. Even the hoover sound (which is annoying on its own) found use in a ghost story where the ghost was caught using a "ghostbuster" hoover.

Observations during the exercise combined with analysis of the way sound was used in these stories allow us to identify several roles (see margin) for sounds that need to be kept in mind when creating interesting wearables, toys and experiences.

Summary

The present paper reports on an exploration into the hedonistic qualities of sound and touch as experienced by visually impaired children. We report on a mixed study design which combined standard elements as questionnaires and focus groups with more innovative creative workshops where tangible representations of different sounds made it possible to physically manipulate the sounds physically in order to create simple, but interesting interactive objects. To further explore how sounds could be used for storytelling (children often tell stories during play) we were able to add a location based sound-story creation exercise which allowed us to identify several roles for the sounds in storytelling and potentially during play, that needs to be considered: facilitate creation, sound effects, story elements, ambience and inspiration.

A takeaway lesson is that preferences vary, indicating a need for flexibility and personalization. Even so, sine or square tones are less liked, while sounds with more harmonics (wider frequency content) are in general better appreciated. Moreover, long continuous sounds are in general considered more unpleasant than short or repetitive sounds. Birds and water sounds are generally popular, while sharp, sudden and loud sounds are disliked – but it should be noted that the unpleasant or drastic also has a role to play. Thus explosions, bangs etc may be of use when creating motivating toys. This is in agreement with [4] where it is stated that such sounds cause high levels of engagements. One sound parameter which should be explored further is rhythm.

For tactile materials, soft, furry and hard materials are appreciated, while sharp, rough, hard, sticky, rubbery and runny materials are less liked. Thus, materials common in toys/play materials like finger paint, play dough, balloons and rubber toys are not always appreciated by children with visual impairments. This is something anyone designing for this group needs to take into account.

The presented study forms the basis for further design of a combination of wearable, mobile and tangible artifacts within the ABBI project.

Acknowledgements
The authors gratefully acknowledge support from the EU for the ABBI project. In addition we thank VINNOVA for supporting the UUT project.

References
1. Gori, M., Sandini, G., Martinoli, C., and Burr, D. (2010). Poor haptic orientation discrimination in nonsighted children may reflect disruption of cross-sensory calibration. Curr Biol 20, 223-225.
2. Cappagli, G., Baud-Bovy, G., Sandini, G., Gori. M., Auditory-motor training improves audio spatial localization. 9th Forum of Neuroscience, Milan 2014
3. Druin, A., (2002) The role of children in the design of new technology, Behaviour & Information Technology, 21:1, 1-25, DOI: 10.1080/01449290110108659
4. McElligott, J., van Leeuwen, L., 2004. Designing sound tools and toys for blind and visually impaired children. In Proceedings of the 2004 conference on Interaction design and children: building a community (IDC '04). ACM, New York, NY, USA, 65-72.
5. Bergman, P., The role of embodied emotions in perceptual decisions and categorization of sounds, PhD Thesis, Chalmers University of Technology, Sweden
6. Etzi, R., Spence, C., Gallace, A., Textures that we like to touch: An experimental study of aesthetic preferences for tactile stimuli Consciousness and Cognition, Vol. 29 (October 2014), pp. 178-188
7. Walker, B. N., & Lane, D. M. (2001). Psychophysical scaling of sonification mappings: A comparision of visually impaired and sighted listeners. In Proceedings of the 7th International Conference on Auditory Display (pp 90-94) Espoo, Finland: ICAD
8. Warner, Daniel; Cox, CChristoph (2004). Audio Culture: Readings in Modern Music. London: Continiuum International Publishing Group LTD. pp 13, ISBN 0-8264-1615-2.
9. Rasch, R., Plomp, R., 1999, The perception of musical tones, D. Deutsch (Ed.), The psychology of music, Academic Press, San Diego (1999), pp. 89–112
10. Bresciani, J-P., Dammeier, F., Ernst, M.O., Vision and touch are automatically integrated for the perception of sequences of events Journal of Vision April 20, 2006 vol. 6 no. 5 article 2