

Vocal and Tangible Interaction Crossing Borders

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Abstract

Our voice and body are important parts of our self-expression and self-experience for all of us. They are also essential for our way to communicate and build relations cross borders such as abilities, ages, locations and backgrounds. Voice, body and tangibility gradually become more important for ICT, due to increased development of tangible interaction and mobile communication. The voice and tangible interaction therefore also become more important for the Universal Design field. In this paper we present and discuss our work with voice and tangible interaction in our ongoing research project RHYME. The goal is to improve health for families, adults and children with disabilities through use of collaborative, musical, tangible and sensorial media. We build on use of voice in Music Therapy, knowledge from multi-sensory stimulation and on a humanistic health approach. Our challenge is to design vocal and tangible interactive media that are sensorially stimulating. Interactive media that through use reduce isolation and passivity and increase empowerment for all the users. We use sound recognition, generative sound synthesis, vibrations and cross-media techniques, to create rhythms, melodies and harmonic chords to stimulate voice-body connections, positive emotions and structures for actions.

Keywords

Voice, Tangible Interaction, Sound, Empowerment, Resource-oriented, Music & Health, Music Therapy

Introduction

Traditionally, ICT for persons with disabilities, so called Augmentative and Alternative Communication (AAC) technologies have focused on interaction with screen based visual graphics and text. The interest for embodied and tangible interaction [16, 17] has grown, though, because of the development in mobile communication, computer gaming and social media. Compared to traditional ICT and AAC technologies, tangible technologies are computer based and therefore have unique abilities to memorise and learn. They also have unique qualities for the user due to the use of the body, touch, hearing, voice and music, as a complement to visuals and text. These qualities have made them accessible for large groups of people, earlier excluded that are now motivated to participate and cross borders. Motivated to cross from being a more or less passive disabled spectator, to a music creator, playing games an engaging socially with other people. To cross borders in this active, creative and social meaning, in many cases also means to *break with personal social or physical boundaries*.

In this paper we explore the voice in tangible interaction design and its possibilities to strengthen health by reducing isolation and passivity. Our approach is to use knowledge from Music Therapy and Multi-sensory stimulation for designing computer-based tangible interaction. We argue that these two fields' use of resource-oriented methods that strengthens all participants involved are particularly interesting for Inclusive Design when working with a diverse mix of people with and without disabilities. In two design cases, we explore vocal and bodily, tactile interaction as input, and musical, tactile and lighting as output. The two cases are first and second generation of interactive, tangible installations in our ongoing research project RHYME [34]. To analyse and integrate the findings in the design we have followed user oriented research-by-design methods conducted as cycles of actions with design, interviews and video observations with families with children with severe disabilities.

Related work

Vocal and tangible interaction

Our approach is multi-disciplinary and based on earlier studies of *voice* in resource-oriented Music and Health research and Music Therapy [5, 7, 23, 25] identifying how music works by strengthening voice-body relations, *positive emotions* and create *structures for actions*. Further, our approach is based on research from the fields of Tangible Interaction in Interaction Design [16,17, 27], voice recognition and sound synthesis in Computer Music [35, 45] for interacting persons with laymen expertise [1] that use Assistive Technologies [28, 29]. Vocal and Tangible Interaction has spread with computer games such as the *Nintedo Wii's* [31], improving strength and balance [32]. Music creation and gaming are combined in *GuitarHero*, and voice controlled karaoke game *SingStar* [21, 26]. Often, though, the interfaces do not suit a person's individual needs. Therefore the design for persons with disabilities and has led to development of switch based interfaces such as *Paletto* [22] and ultrasound sensor *Soundbeam* [42]. *Soundbeam* triggers notes in a synthesiser and is used for rehabilitation. Assistive Technologies like *Paletto* and *Soundbeam* have in common that they support direct response with the goal to give the user clear feedback. There are however mayor drawbacks. It can be hard for persons with severe disabilities to master, because the strong focus on direct feedback creates expectations that a person with severe physical disabilities might never be able to meet. As a result, the individual can experience demotivation instead of mastering. The mechanical repetitiveness can lead to fatigue [29] with the risk to disempower rather than empower [13, 33, 36, 37] the person interacting. Finally, when the therapist is leaving the room, the device (instrument, switch-based controller) in practice stops working because it depends on the therapist's actions. Therefore the person with disability either becomes over-stimulated or isolated. Meanwhile, other successful methods and practices are being used within traditional computer gaming and Interactive Music and Art. Very few, though, of the existing computer-based and interactive devices for health improvement consider the knowledge in these fields of Music and Health for cultural reasons. Our suggestion as designers is to look for inspiration among the Music Therapy practices and adapt them for computer-based media.

Voice, Music and Health

Listening, playing and dancing to music motivate people to create and socialise in all cultures, to cross borders between age, background, culture, cognitive, social and physical abilities. Music is both a highly virtuoso activity and has long cultural traditions among people with layman expertise [15]. Music is therefore a fantastic “cultural material” [4] to dig into when designing. Many amateurs have life-long music memories strongly tied to emotions and development of social and individual self. When growing up, music is often used as a medium for breaking boundaries of social rules, and to form one's own identity.

Music and Health is a research field that has expanded the music therapeutic situation into everyday life [38]. *Music and Health* research complements biomedical, cognitive, psychological, methods with *humanist*, cultural and ecological approaches [6, 38]. Instead of only focusing on diagnosis and illness, *Music and Health* is *resource-oriented* [36, 37], and no matter how weak or ill, it is always possible to motivate a person to use her resources with the purpose to *empower* all persons involved in a relation in a certain situation. The positive psychology [39] and resource-oriented [36, 37] approach that we practise, that there are no wrong actions, is connected to musicologist Christopher Small's term *Musicking* [26]. Small sees music as an ongoing, everyday *relation building activity*, like the song writing activity above. Not as an Art object but as a verb – *to music*. The approach involves everyone in an amateur community or family to interact and potentially get empowered

Voice in Music Therapy

“Being an inner instrument of the body, the voice is at a unique and powerful vantage point for working with the self from within” as music therapist Kenneth Bruscia writes [7:357]. The voice is powerful and yet vulnerable since it is constantly in contact with our body through breathing. The voice is vulnerable because it reveals a person's emotions and expresses her identity [38, 42, 7:359]. Music therapist Joanne Loewy brings forward four complementing models for working with voice throughout a person's life and in different situations. Models for *prelinguistic* stages, in *developing* a language and a personality, for *recovery*, both listening and creating vocal sounds after severe damage to the brain or trauma, and with voice and *psychotherapy* [25].

The music therapist uses *rhythm*, *melody*, *harmony* and *speech* as working tools. Rhythm is used to motivate a person to *enhance motoric* and *vocal play*, *stressing borders* and *strengthen* the person's *sense of self*. Sharp separated sounds such as the consonants “S”, “K”, “T”, “P” increase the rhythm in vocal interaction. *Melody* are based on tones, joining events together in sequences, and music therapists use it to localise and open up emotions and parts of the body [41]. *Harmonizing* is to simultaneously play two voices on separate notes. In Music Therapy it is used to explore situations of separations and relationship between voices [5:8] belonging to the same chord. The music is a safe environment and a “test-bench” for trying out difficult emotions.

The Therapeutic Voice

Voice in Music Therapy can be used to create *voice-body* relations, to evoke *positive emotions* and to provide *structures for actions*. In therapy, voice is used for developing

relations to the individual's own *body*, through singing and holding the tone while finding and freeing an emotion or part of the body [5]. In therapy the body can extend to relations to other persons and their bodies, recognising voices belonging to a functional *family body* and even a *cultural body* as in music therapist Lisa Sokolov's *Embodied Voice Work* [41, 7]. Voice is used to evoke *positive emotions*, and to empower all persons to use their resources, weak or strong. It is part of the empowering and resource-oriented approach that is common within Music Therapy [23, 24]

Music is important in *prelinguistic* stages. Before a child develops a verbal language she uses musical non-verbal communication to explore her own body and mirroring relations with her mother and others. Rhythms, melodies and harmonising are used to ground a person in her body and to evoke positive emotions. They are also used as *structures for actions*, that facilitate actions for identifying difficult emotional and physical boundaries and breaking with those boundaries [41, 7]. Often the actions have as goal to empower people to make things by their own will, or to break with a negative behaviour. This is described as 4 phases from 1. *Exploring* the difficult boundary through use of one's voice, listening and trying to 2. *Release* emotions and *Strengthen* one's person, 3. *Integrating* the new knowledge and techniques into everyday actions, and finally seek 4. *Independence* and to break with the therapist [7:359]. *Harmonizing*, through chord changes and harmonic modulation, supports and helps *recast* the music and emotions that a person has when listening and creating music. By changing chord and style the voice of the person is put in another musical context than before, and is therefore *recasted* and given a *different role* [41, 7:358]. It can empower the person, who the voice belongs to, to integrate emotional conflicts by overcoming them, acting out the emotions in a chord of two co-existing tones.

Melodies are used to focus on emotions and parts of the body by singing extra long notes. With these *vocal holding techniques* [5], the therapist provides the means to explore sound, breathing and voice.

The RHYME Project

Project Goals and Approach

The context for this paper is the RHYME research project between the Oslo School of Architecture and Design, Centre for Music and Health at the Norwegian Academy of Music and the University of Oslo [34]. The project goal is to improve health and life quality for persons with severe disabilities, through the use of *vocal and tangible interactive media*. In the project we develop prototypes, focusing on different user situations, from multimodal, mobile to social media.

RHYME is based on a humanistic health approach [6, 38]. The goal is to reduce isolation and passivity through use of vocal and tangible interactive media. The first empirical study in the RHYME project was of the vocal and tangible interactive medium *ORFI* (see Fig. 1) made by three of the members of RHYME [30]. Prior to the RHYME project it had been tested and documented with video observations and interviews with adults and children at the Rosenlund public hospital in Stockholm.

Later in the RHYME project, *ORFI* was observed with 5 children, between 7 and 15 years old with special needs, in their school's music room with a closely related person, not professional music therapists. We made 4 different actions over a period of 1 month. We made weakly changes based on the previous action. The second empirical study at

the school was of *Wave* (see Fig. 2) following the same schedule as in *ORFI*. All sessions were video recorded to be presented for a cross-disciplinary focus group for further analysis. The health aspects are described by music therapists Dr. Karette Stensæth and Professor Even Ruud [43, 44].

Designing ORFI

ORFI (fig. 1) is a vocal and tangible interactive installation. It consists of 20 mobile soft triangular shaped cushions or modules in three different sizes with speakers, microphones, LED-lights, generative graphics projection and sensors, reacting to bending and singing. *ORFI* has been studied from the perspectives of Tangible Interaction [9, 11, 12] Health [43, 44], Computer Music and Interactive Audio [1, 2, 10], Assistive Technology [13] and Universal Design [8]. *ORFI*'s software, made with real-time audio-synthesis programming language SuperCollider [45] makes it possible to change the sound dynamically. It leads to greater flexibility to change the music and give relevant direct responses. *ORFI* has 8 different music genres, where one is the voice based VOXX. *ORFI* has separate modules with microphones that record and manipulate people's singing with delay, time-stretch and cut-up effects, but keep the voice recognisable. We have designed *ORFI* so that a user can select any module at any time, and interact with it over a long time. A user can change and develop the musical variation as well as *shifting* [24] what role to play from exploring alone, to creating music and playing with others, or just relaxing.



Figure 1: Interacting in *ORFI* Figure 2: Family interacting in *Wave*

Designing for voice-body, positive emotions and structures in *ORFI*

The speaker modules in *ORFI* are mobile, soft, lightweight, vibrate wirelessly and can be hugged and lifted up into the lap. It makes it easy to feel the rhythms and tones onto the body. The mobile microphones and speakers make it possible to feel the voice onto the body potentially creating voice-body relations like *vocal holding* in the Music Therapy sense [41, 7]. To motivate *positive emotions* we use musical rules in the software adding effects to the sound. For example pitch-up-effects, and loop to a rhythmic beat that create funny, rhythmic sound effects. *ORFI* contributes to the *structures for actions*, as the individual records a vocal sound into a microphone module and finding it as the software places it into one of the other modules, through music making, play, and relaxation.

Design for border crossings in ORFI

ORFI motivates to cross the *age border* with the 8 different musical scenes based on different music styles from different times such as jazz, noise, funk, minimalistic, chamber orchestra music, etc. Showing interest in musical style has been used to reveal what a person remembers and in what age and cultural group the person belongs to [23]. *Openness* [18] for different interpretations and the use of *ambiguity* [20] as aesthetical qualities, have been used to design a floating border between *ORFI* as a toy, instrument, and soundscape environment to relax in. That it can be interpreted as a teddy bear by a person taking a kid's perspective, and at the same time as a furniture by a person interested in Interior Design, an instrument by the musically interested, etc. By being wireless *ORFI* motivates to cross the *location border* with the possibility to spread all the 20 modules in a radius of 100 metres. *ORFI* motivates to cross the borders of different personal *backgrounds*. For instance between employed health worker and their clients and at the same time giving direct response to the beginner, rhythmic patterns for people that want to dance, play together and collaborate and creative variations challenging the music professional.

Designing Wave

When designing *Wave Carpet* (fig. 2) our objective was to combine many more media types, than in *ORFI*. The goal was to explore the potential for rich cross-media interaction among several persons. The solution became *Wave*, a big seven-branched carpet, where all branches or arms have different functions and sensors, all with LED-light feedback. The thick landscape carpet has stereo speakers and a heavy vibrating transducer in the middle. *Wave* projects generative graphics from a small handheld laser projector in one arm connected to a camera combined with microphone in another arm, adding delay-echo effect to the sound. In addition *Wave* has a separate microphone that records the user's voice in a third arm. The recording is played back when the user interacts with two other arms reacting to shaking (accelerometer). Shaking adds funny sounding pitch shift effects to the voice. One small arm is used for pitching up and one large for pitching down the sound. The last two arms have bend sensors playing looping base melodies. The advanced real-time sound design, sound synthesis and effects are made in the SuperCollider programming language [45].

Wave has been studied from the perspectives of tangible interaction [9, 11] health [3], computer music [2, 3], Assistive Technology [13] and Universal Design [8].

Designing for voice-body, positive emotions and structures in Wave

We designed *Wave* with stronger stereo speakers and vibrating transducer or "butt-kicker", used in cars to create heavy vibrations. It made it possible to explore *voice-body* relations [41, 7], motivating bodily interaction, such as sitting, hugging and relaxing in *Wave* that wasn't possible in *ORFI* with weaker speakers and no transducer.

The potential for *positive emotions* [39] is created in *Wave* with possibilities to record without preparation or other interactions than holding and talking into the glowing microphone arm. The flow can be maintained by adding effects interacting with the two arms with accelerometers.

The software and tangible design, with separate arms for record and play, provide *structures for actions* for several persons. It makes it more motivating to record and play

if you are two than one. Instead of isolating touch and bend sensors to one specific part they are spread out to make it more playful and motivating to get feedback from any part. *Wave* further makes it possible to add rhythmic beats that change tempo and timbre qualities dynamically with interaction, also affecting the generative graphics projected on the wall with one small graphical circle per arm that is being moved.

Design for border crossings in Wave

Wave's 7 arms with many different functions being possible to select at one time motivates to cross the border of different *abilities*. One person can lie down and talk into the microphone while another change the sound with the two arms with accelerometers. *Wave* motivates to *cross age borders* by sounding like a toy-parrot with the pitch shift effect, motivating children to interact. Further by referring to a carpet and furniture, motivating adults to sit or lie down in it, or an instrument to play on.

Wave's glowing led light on every sensor motivates to *cross location borders*. Compared to *ORFI*, the lighting in *Wave* strengthens the awareness of the different locations where it is possible to interact and therefore motivates interaction.

Wave's tangible form referring to different actors such as a sofa, floor carpet, instrument, toy and cushion to sleep in, motivates to *cross borders between backgrounds and cultures*. If a person who lies down with an interest in *Wave* as sofa, hears somebody else singing, he or she can shift to singing, viewing *Wave* as an instrument.

Two user-stories

Deaf David Crossing Borders in ORFI

David uses a wheelchair, has impaired hearing and loves music. First it seems as a contradiction, but David listens through vibrations. Normally this is hard for David since most speakers are too heavy for him to lift up and into his wheelchair. In *ORFI*, though, he plays sound, holding one of the small soft and light speaker cushions in his lap, "listening" to the assistant's voice, through the vibrations. According to his assistant, David likes to explore the relations between music and body [41, 7]. He is deaf since birth but in *ORFI* he starts to imagine which songs to bring with him the next time. A defining moment in the first session is when David realises that he can *record his own voice*. He starts to cry. David has never heard his own voice and even if he can't create many sounds when he tries it the first time, he is determined to go home and practice.

To summarise, we observed the user David as he and *ORFI* created:

- *Voice-body connections*. The user was motivated to lift up and feel vibrations from *ORFI's* speaker modules on his lap. He was motivated to use his voice to create sound he could "hear" from sensing the vibrations and feel his voice.
- *Positive emotions*. *ORFI* promoted *positive emotions* by motivating the user to master. Whatever the users did, *ORFI* answered, inviting to further interaction.
- *Structures for actions*. *ORFI* offered *structures for creative actions* as the user went home to prepare music to sample in the next session. *ORFI* offered *structures for vocal actions* as the user at first couldn't make vocal sounds, but was motivated to practice to be able to record and play with his voice in *ORFI*.

Based on the above we observed how the users *crossed borders* of:

- *Abilities.* *ORFI* motivated the users to cross borders between *abilities* as he went home to practice something he didn't think would be possible: To master his voice and "hear" his voice through vibrations. Through developing voice-body connections and through being offered alternative structures for actions in *ORFI* the user *broke the boundary* of not hearing and not being able to sing. He made an obstacle into a positive challenge. Instead of feeling passive and excluded the user's actions with *ORFI* strengthened wellbeing, mastery and relations to people as he could contribute socially by singing.
- *Locations.* *ORFI* motivated the user to cross borders of *locations* as he broke the boundary between the institution, where he had his rehabilitation and his home.
- *Backgrounds.* The possibility to sample his own music made it possible to cross the borders of *backgrounds* as the user went from a person with disabilities to a connoisseur interested in salsa music, sharing interest with the group.

Wendy Crossing Borders in Wave

Wendy is a 15-year-old girl with Down syndrome. She likes to sing but is shy. She records her voice, in one of *Wave's* glowing arms and recites names of favourite dishes like "Taco" and Pizza". The assistant interacts with the two arms and pitches the recording up and down. Wendy laughs at the parrot-like pitch effect. Wendy lies down, on top of the transducer with heavy vibrations and tangible responses. The vibrations from the beat in the synthesised voices in *Wave* makes her calm and safe as she feels the bass rhythms on her body. In a safe environment Wendy takes initiative. Instead of being withdrawn, she and her assistant collaborate and create melodies with voice that they manipulate and vibrate throughout *Wave* and make them giggle. *Wave* is programmed to analyse melodic events built up from binding vowels and separating consonants as described above under *Voice in Music Therapy* [7:358, 41]. On increased and repeating interaction, the timbre of the sound changes towards sharp percussion sounds and FM-synthesis and high-pass filtering effects. Wendy holds on to certain sounds, where the binding vowels are supporting her actions. She also reacts to sharp consonants and timbre changes that help her separate between sounds and increase her sense of mastering [7:358, 41]. Wendy and her assistant improvise together as the assistant toggles between the last three sounds playing with the arms and Wendy continues to record new words in parallel.

To summarise, we observed the user Wendy, her assistant and *Wave* create:

- *Voice-body connections.* Wendy sang as she lied on the vibrating transducer.
- *Positive emotions.* The user's self-created vibrating vocal holding [41, 7] made it possible for her to explore her voice in a safe environment away from prying class mates teasing her for her home work in speech therapy.
- *Structures for actions.* Wendy relaxed as *Wave* offered her and the assistant fun feedback, playing around with her homework. Wendy and her assistant negotiated the meaning of the words and the manipulations as they went on interacting, varying the sound of Wendy's voice, *improvising together*.

Based on the above we observed how the users *crossed borders* of:

- *Abilities*. Motivated Wendy to use her voice. To explore the musical potential of the words. Wendy and her assistant developed new roles to each other, from being a person with disabilities and an assistant, to musicians playing as a group.
- *Ages*. *Wave* motivated the young user and her adult assistant to develop an understanding of the vocal possibilities of *Wave* crossing the borders of *ages*.
- *Locations*. *Wave* motivated the assistant and Wendy to cross the borders of locations, from their interaction at an office desk to relaxing on *Wave* Carpet.
- *Backgrounds*. Interpretations that made it possible for Wendy to cross the border between different *backgrounds*. Interpreting *Wave* as a playful octopus she took the role of a player. Viewing *Wave* as an instrument she mastered it. As furniture, *Wave* offered her a vibrating and safe sofa where she took the role of relaxing.

Conclusion

Our voice and body are important ways to communicate and build relations cross borders such as abilities, ages, locations and backgrounds. In two design cases of vocal and tangible interactive media, we have adopted vocal composition and improvisation techniques from Music Therapy, with the goal to inform our own design practices in the field of Inclusive Design. Traditionally music therapists' techniques are used to create rhythms, melodies and harmonic development, in order to motivate activity, voice-body connections, social interaction and evoke positive emotions. In the cases we have showed how they can be designed in order to motivate vocal and tangible interaction, through the strengthening of voice-body connections. For instance with the use of *vocal holding techniques* creating sound and vibrations on the body for calming and soothing, or for putting focus on breaking difficult boundaries. We show how we have adopted Music Therapy's notion of *structures for actions* to design musical rules and tangible hardware that change and create expectations for future events over time and space. We have showed how vocal and tangible interaction has been able to address issues of crossing borders. Borders of abilities between "patient" and "care giver". In this sense vocal and tangible interaction has been successful in breaking individual and social boundaries.

Acknowledgements

We thank Fredrik Olofsson [30] for his creative contribution and The Research Council of Norway (VERDIKT) for financing the RHYME project [34].

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