Vocal and tangible interaction in RHYME

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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 of communicating and building relations across borders such as abilities, ages, locations and backgrounds. Voice, body and tangibility gradually become more important for information and communication technology (ICT), due to increased development of tangible interaction and mobile communication. The voice and tangible interaction therefore also become more important for the fields of assistive technology, health technology and universal design. In this article we present and discuss our work with voice and tangible interaction in the on-going research project RHYME. The goal is to improve health for families, adults and children with disabilities through the use of collaborative, musical, tangible and sensorial media. We build on the use of voice in music therapy, knowledge from multi-sensory stimulation and on a humanistic approach to health. Our challenge is to design vocal and tangible interactive media that are sensorially stimulating and through use can both reduce isolation and passivity and increase empowerment for many users. We use sound recognition, generative sound synthesis, vibrations and cross-media techniques in order to create rhythms, melodies and harmonic chords to stimulate voice-body connections, positive emotions and structures for actions.[1]

Introduction

Traditionally, ICT for persons with disabilities, so called augmentative and alternative aommunication (AAC) technologies, have focused on interaction with screen-based visual graphics and text. However, the interest for embodied and tangible interaction (Dourish, 2004; Dourish & Bell, 2011) has grown because of the development in mobile communication, computer gaming and social media. Compared

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1   This article is not peer-reviewed but is a revision of many peer-reviewed papers and conference proceedings created and held by the authors.

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 who were earlier excluded and are now motivated to participate and cross borders; motivated to cross from being a more or less passive disabled spectator to being a music creator, playing games and 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 article we explore the voice in tangible interaction design and its possibility to strengthen health by reducing isolation and passivity. Our approach is to use knowledge about the voice from music therapy and multi-sensory stimulation for designing computer-based tangible interaction. We argue that the use of resource-oriented methods by these two fields strengthens all participants involved and is particularly interesting for interaction design and computer-based interactive sound design when working with a diverse mix of people with or without disabilities. In two design cases we explore vocal, bodily and tactile interaction as input, and music, tactile sensations and lighting as output. The two cases are first and second generation of interactive, tangible installations in the on-going research project RHYME (Rhyme, 2010). 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 of families with children who have 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 (Sokolov, 1984; Austin, 2001; Bruscia, 1987; Lyngroth et. al, 2006; Loewy, 2004) identifying how music works by strengthening *voice-body* relations, *positive emotions* and creating *structures for actions*. Furthermore, our approach is based on research from the fields of tangible interaction in interaction design (Dourish, 2004; Dourish & Bell, 2011; Löwgren & Stolterman, 2005), voice recognition and sound synthesis in computer music (Roads, 1996; Wilson, Cottle & Collins, 2011) for interacting persons with laymen expertise (Andersson, 2012) that use assistive technologies (Magee, 2011; Magee & Burland, 2008). Vocal and

tangible interaction has spread with computer games such as the *Nintedo Wii* (Nintendo, 2008), improving strength and balance (Nitz, 2010). Music creation and gaming are combined in *GuitarHero*, and the voice-controlled karaoke game *SingStar* (Harmonix, 2005; London, Studio 2004). Often though, the interfaces do not suit a person's individual needs. Therefore the design for persons with disabilities has led to the development of switch-based interfaces such as *Paletto* (Kikre, 2005) and the ultrasound sensor *Soundbeam* (Soundbeam, 1989). *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 major drawbacks. It can be hard for persons with severe disabilities to master assistive technologies supporting a strong focus on direct response, because it 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 (Magee & Burland, 2008) with the risk of disempowering rather than empowering the person interacting (Cappelen & Andersson, 2012b; Renblad, 2003; Rolvsjord, 2010, 2006). Additionally, when the therapist leaves the room the device (instrument, switch-based controller) in practice stops working because it depends on the thera-pist's actions. Therefore, there is a risk that the person with the disability becomes either over-stimulated or isolated.[2] Meanwhile, other successful methods and practices are being used within traditional computer gaming and interactive music and art. However, very few 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 in the area of music therapy practices and adapt them for computer-based media.

Voice, music and health

Listening, playing and dancing to music motivates 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 virtuosic activity and has long cultural traditions among people with layman expertise (DeNora, 2000). Music is therefore a fantastic 'cultural material' (Appadurai, 1986) to dig into when designing. Many amateurs have life-long music memories strongly tied to emotions and development

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2   See also the discussion in Cappelen & Andersson (2014) or elsewhere in this volume.

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 (Ruud, 2010).

Music and health is a research field that has expanded the music therapeutic situation into everyday life (Ibid.). *Music and health* research complements biomedical, cognitive and psychological methods with *humanist*, cultural and ecological approaches (Blaxter, 2010; Ruud, 2010). Instead of only focusing on diagnosis and illness, *music and health* is *resource-oriented* (Rolvsjord, 2010, 2006). No matter how weak or ill, it is always possible to motivate a person to use her own resources with the purpose to *empower* all persons involved in a relation in a certain situation. The positive psychology (Seligman & Csikszentmihalyi, 2000) and resource-oriented (Rolvsjord, 2006, 2010) approach that is practised in RHYME, that there are no wrong actions, is connected to musicologist Christopher Small's term *musicking* (Small, 1998). Small sees music as an on-going, everyday *relation building activity*, not as an art object but as an activity. He therefore uses the verb – *to music*. The approach involves everyone in an amateur community or family to interact and potentially be empowered.[3]

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 (Bruscia, 1987, p. 357).

As music therapist Kenneth Bruscia writes, 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 (Ruud, 2010; Sokolov, 1984; Bruscia, 1987, p. 359). Music therapist Joanne Loewy brings forward four complementing models for working with voice throughout a person's life and in different situations (Loewy, 2004). These are 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*.

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 *strengthening* the person's *sense of self*. For example, sounds that are

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3   Again, see the discussion in Cappelen & Andersson (2014) or elsewhere in this volume.

sharply separated, such as the consonants 'S', 'K', 'T', 'P', help increase the rhythm in vocal interaction. *Melody* is based on tones, joining events together in sequences, and music therapists use it to localise and open up emotions and parts of the body (Sokolov, 1984). *Harmonizing* is to simultaneously play two or more voices on separate notes. In music therapy it is used to explore situations of separation and relationship between voices (Austin, 2001, p. 8) belonging to the same chord. The music can become a safe environment and "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.* 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 (Austin, 2001). In therapy, the body can extend to relations to other persons and their bodies, recognising that voices belong to a functional *family body* and even a *cultural body,* as in music therapist Lisa Sokolov's *Embodied Voice Work* (Sokolov, 1984; Bruscia, 1987). The 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 (Rolvsjord, 2010; Ruud, 2010).

Music is important in the *prelinguistic* stages. Before a child develops a verbal language she uses musical non-verbal communication to explore her own body and to mirror relations with her mother and others. Rhythms, melodies and harmonising ground a person in her body and evoke positive emotions. They are also used as *structures for actions* that facilitate actions for identifying difficult emotional and physical boundaries and for breaking with those boundaries (Sokolov, 1984; Bruscia, 1987). Often the actions are aimed at empowering people to act of their own free will, or to break with a negative behaviour. Bruscia describes this as four phases, starting with:

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 (Bruscia, 1987, p. 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 a new musical context and is therefore *recast* and given a *different role* (Sokolov, 1984; Bruscia, 1987:358). It can empower the person to whom the voice belongs to integrate emotional conflicts by overcoming them, acting out the emotions in a chord of two or more 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* (Austin, 2001), the therapist provides the means to explore sound, breathing and voice.

The RHYME project[4]

RHYME is a five-year interdisciplinary research project (2010–2015) financed by the Research Council of Norway through the VERDIKT program. Its aim is to develop Internet-based, tangible interactions and multimedia resources that have a potential for promoting health and life quality.[5] The project specifically addresses the lack of health-promoting interactive and musical information and communications technology (ICT) for families with children with severe disabilities. RHYME explores a new treatment paradigm based on collaborative, tangible, interactive Internet-based musical 'smart things' with multimedia capabilities. Within the project, these interactive and musical tangibles are called 'co-creative tangibles' (CCTs). The goal of RHYME is twofold: (1) to reduce isolation and passivity, and (2) to promote health and well-being. The RHYME research team represents a collaboration among the fields of interaction design, tangible interaction, industrial design, universal design and music and health that involves the Department of Design at the Oslo School of Architecture and Design, the Department of Informatics at the University of Oslo and the Centre for Music and Health at the Norwegian Academy of Music. The project encompasses four empirical studies and three successive and iterative generations of CCTs, to be developed in collaboration with the Haug School and Resource Centre, the users and the families. Its user-oriented research incorporates the users' influence on the development of the prototypes in the project. The users include from six to ten families who have volunteered to participate, and the children with disabilities in these families range from seven to fifteen years old. The children vary considerably in terms of behavioural style, from very quiet and anxious to cheerful and rather active, but all of them become engaged in enjoyable activities when these activities are well facilitated for them. The most extreme outcomes of the variation in behavioural style relate to disability conditions, and mostly those within the autistic spectrum, which applies to four of the children. These conditions include poor (or absent) verbal language and rigidity of movement. Also, the children's mental ages range from six months to seven years, and their physical handicaps range from being wheelchair dependent to being very mobile. The Norwegian Social Science Data Services approved the RHYME project in February 2011, provided it would gather, secure and store data according to the standards of ethics in Norwegian law.

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4   The section inside the frame below is similar in all of the RHYME articles in this anthology, *Music, Health, Technology, and Design* by Stensæth (Ed.).
5   For more about the health potential found in the testing of the CCTs, see elsewhere in this anthology or in Eide (2014), Stensæth & Ruud (2014) or/and Stensæth (2014a, b).

Project goals and approach

A project goal in RHYME is to improve health and life quality through the use of *vocal and tangible interactive media*. In the project we develop prototypes, focusing on different user situations, from multimodal, to mobile to social media. RHYME is based on a humanistic health approach (Blaxter, 2010; Ruud, 2010). The first empirical study in the RHYME project was of the vocal and tangible interactive medium *ORFI* (see picture 1) made by three of the members of RHYME (MusicalFieldsForever 2000). Prior to the RHYME project ORFI had been tested and documented with video observations and interviews with adults and children at a public hospital in Stockholm. Later in the RHYME project, ORFI was observed with the participating children, between 7 and 15 years old with special needs, in their school's music room together with assistants who knew the children well (also called 'close others' in RHYME). The RHYME team prepared the experiments in four different rounds, also called 'actions'. These actions took place over a period of one month. The team made weekly changes based on the previous actions. The second empirical study at the school was of WAVE (see picture 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 in the articles written by the music therapists Eide, Stensæth, and Ruud (see Eide, 2014; Ruud, 2014; Stensæth, 2014, 2013, Stensæth & Ruud, 2014, 2012).[6]

Designing ORFI[7]

ORFI (Picture 1) is a vocal and tangible interactive installation. It consists of 20 mobile soft triangular shaped cushions or modules in three different sizes. Inside the cushions there are speakers, microphones, LED-lights, generative graphics projection and sensors that react to bending and singing. *ORFI* has been studied from the perspectives of tangible interaction (Cappelen & Andersson, 2011a, 2011c, 2012a), health (Eide, 2014, 2013; Stensæth, 2014a, b, 2013; Stensæth & Ruud, 2014, 2012), computer music and interactive audio (Andersson, 2012; Andersson & Cappelen, 2013; Cappelen & Andersson, 2011b), assistive technology (Cappelen & Andersson, 2012b) and universal design (Cappelen, 2012). ORFI's software, made with the real-time audio-synthesis programming language SuperCollider (Wilson,

6   See also Stensæth, Holone & Herstad (2014) or elsewhere in this volume.
7   Read about how two children interacted with ORFI in the article written by Stensæth & Ruud (2014) elsewhere in this volume.

Picture 1: *Father and son playing with ORFI*

Picture 2: *Family playing with WAVE*

Cottle & Collins, 2011) makes it possible to change the sound dynamically. It leads to greater flexibility in changing the music and gives relevant direct responses. ORFI has eight different music genres, where one is the voice-based VOXX. ORFI has separate modules with microphones that record and manipulate singing with delay, time-stretch and cut-up effects, but keep the voice recognisable. ORFI is designed so that the person who interacts with it can select any module at any time and interact with it over a long span of time. A user can change and develop the musical variation as well as *shifting* (Latour, 1999) from one role to another: from exploring alone to creating music and playing with others, or just relaxing.

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

The speaker modules in ORFI are mobile, soft, and lightweight, vibrate wirelessly and can be hugged and lifted up into the lap. This makes it easy to feel the rhythms and tones on the body. The mobile microphones and speakers make it possible to feel the voice on the body, potentially creating voice-body relations like *vocal holding* in the music therapy sense (Sokolov, 1984; Bruscia, 1987). To motivate *positive emotions* we use musical rules in the software to add effects to the sound: pitch-up-effects and looping to a rhythmic beat create funny, rhythmic sound effects. ORFI contributes to the *structures for actions*, as the individual records a vocal sound into a microphone module and then, as the software places it into one of the other modules, finds it again through music making, play, and relaxation.[8]

Design for border crossings in ORFI

ORFI motivates to cross the age border with the eight different musical scenes based on different music styles from different times such as jazz, noise, funk, minimalistic, chamber orchestra music, etc. Showed interest in musical style has been used to reveal what a person remembers and in what age and cultural group the person belongs to (Lyngroth et. al, 2006). *Openness* (Eco, 1979) to offer many potential and different interpretations, and *ambiguity* (Gaver, Beaver & Benford, 2003) as an aesthetical quality, has been used to design a floating border between ORFI as a toy, instrument, and soundscape environment to relax in. Thus, it can be interpreted as a teddy bear by a person taking a child's perspective and at the same time as furniture by a person interested in Interior Design or as an instrument by the musically interested, etc.

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8   Read about two children's playing with ORFI in Stensæth & Ruud (2014) or elsewhere in this volume.

By being wireless, ORFI motivates to cross the *location border* with the possibility of spreading all of the 20 modules throughout a radius of 100 metres. ORFI motivates to cross the borders of different personal backgrounds, for instance between employed health worker and their clients. At the same time it gives 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 (picture 2) our objective was to combine many more media types than those present 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 one for pitching down the sound. The other 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 (Gaver, Beaver & Benford, 2003).

WAVE has been studied from the perspectives of tangible interaction (Cappelen & Andersson, 2011a, 2011b), health (Andersson & Cappelen, 2014; Stensæth, 2014a), computer music (Andersson & Cappelen, 2014, 2013), assistive technology (Cappelen & Andersson, 2012b) and Universal Design (Cappelen, 2012).

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

We developed WAVE with stronger stereo speakers and vibrating transducer or 'butt-kicker', used in cars to create heavy sound vibrations. This made it possible to explore *voice-body* relations (Sokoler, 1984; Bruscia 1987), 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* (Seligman & Csikszentmihalyi, 2000) is created in WAVE with possibilities to record without preparation or other interactions other 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 there are two users rather than just one. Instead of isolating touch and bend sensors to one specific part they are spread out so that feedback comes from any part, making the experience more playful and motivating. Furthermore, WAVE 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 seven arms with the possibility of selecting many different functions at any one time motivates users to cross borders of different *abilities*. One person can lie down and talk into the microphone while another changes the sound with the two arms with accelerometers.[9]

WAVE motivates to *cross age borders* by sounding like a toy-parrot with the pitch shift effect, motivating children to interact. By referring to a carpet and furniture, it motivates adults to sit or lie down on it, or to use it as 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 with an interest in WAVE as a sofa lies down and hears somebody else singing, he or she can shift to singing, therefore viewing WAVE as an instrument.

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9   Read about Petronella's playing with the microphone in WAVE in Stensæth (2014a) or elsewhere in this volume.

Two short user observations
David crossing borders in ORFI

'David' is a person who loves music.[10] He uses a wheelchair and has impaired hearing. At first it seems like 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 sounds, 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 (Sokolov, 1984; Bruscia, 1987). He is deaf since birth, but in ORFI he starts to imagine which songs he would 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 cannot 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 the following:

- *Voice-body connections*. David 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 sounds he could "hear" from sensing the vibrations and feeling his voice.
- *Positive emotions*. ORFI promoted *positive emotions* by motivating David to master. Whatever he did, ORFI answered, inviting further interaction.
- *Structures for actions*. ORFI offered *structures for creative actions* as David went home to prepare music to sample in the next session. ORFI offered *structures for vocal actions* as David at first could not 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 David to cross borders between *abilities* as he went home to practice something he did not 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,

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10 David is not a participant in RHYME. He explored ORFI outside the RHYME test situations.

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 being a person with disabilities to a connoisseur interested in salsa music, sharing interest with the group.

Petronella crossing borders with WAVE[11]

Petronella is a 15-year-old girl with Downs syndrome. She loves music and likes to sing, but is sometimes shy. She records her voice in one of WAVE's glowing arms and recites names of favourite dishes like 'Taco' and 'Pizza'. Her assistant interacts with the two arms of the WAVE and pitches the recording up and down. Petronella laughs at the parrot-like pitch effect. Petronella lies down, on top of the transducer with heavy vibrations and tangible responses. The vibrations from the beat in the synthesised voices in WAVE make her calm and feel safe as she feels the bass rhythms on her body. In a safe environment Petronella takes the initiative. Instead of being withdrawn, she and her assistant collaborate and create melodies with their voices that they manipulate and vibrate throughout WAVE. This makes them giggle. WAVE is programmed to analyse melodic events built up from binding vowels and separating consonants as described above in the section called *Voice in music therapy* (see also Bruscia, 1987, p. 358, Sokolov, 1984). On increased and repeated interaction, the timbre of the sound changes towards sharp percussion sounds and FM-synthesis and high-pass filtering effects. Petronella 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 to distinguish the sounds and increase her sense of mastering (Ibid.). Petronella and her assistant improvise together as the assistant toggles between the last three sounds by playing with the arms, and Petronella continues to record new words.

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11 Read about Petronella exploring the WAVE carpet in Stensæth (2014a) or elsewhere in this volume.

To summarise, we observed the user Petronella, her assistant and WAVE create:

- *Voice-body connections.* Petronella sang as she lay on the vibrating transducer.
- *Positive emotions.* Petronella's self-created vibrating vocal holding (Ibid.) made it possible for her to explore her voice in a safe environment.
- *Structures for actions.* Petronella relaxed as WAVE offered her and the assistant fun feedback, playing around with her homework in speech therapy. Petronella and her assistant negotiated the meaning of the words and the manipulations as they went on interacting, varying the sound of Petronella's voice, *improvising together*.

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

- *Abilities.* Petronella was motivated to use her voice, to explore the musical potential of the words. Petronella 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* hence crossing the borders of *ages.*
- *Locations. WAVE* motivated the assistant and Petronella to cross the borders of locations, from their interaction at an office desk to relaxing on the *WAVE* Carpet.
- *Backgrounds*. Interpretations that made it possible for Petronella 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 in which to communicate and build relations across 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 of informing our own design practices in the field of interaction design, assistive

technologies, musicology and interactive sound design. Traditionally, the music therapists' techniques are used to create rhythms, melodies and harmonic development, in order to motivate activity, voice-body connections and social interaction and to evoke positive emotions. In the subsequent observations we have shown 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 have shown 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 in time and space. We have shown how vocal and tangible interaction has been able to address issues of crossing borders, like those of abilities between 'patient' and 'care giver'. In this sense vocal and tangible interaction has been successful in breaking individual and social boundaries. Lastly, we thank Fredrik Olofsson in the MusicalFieldsForever (2000) for his creative contribution and collaboration on the design and the development of the musical and interactive tangibles.

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