

# Towards an Empowering Tangible Interaction Design for Diversity

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## **Abstract**

The seven principles of Universal Design, such as "4. Perceptible Information" and "5. Tolerance for errors", are formulated from the design's or system's perspective. The principles focus on the *qualities of the system or design*, not on the *value of use*, the *long time experience* and use by *many different* people. Nor do the principles embrace a *cultural and social understanding* of the *value of things, designs and situations*.

In this paper we argue for the necessity to broaden this narrow system or product design perspective, when designing to empower diverse users. Our field of study is musical and cross-media Tangible Interaction Design, where multimedia computer capabilities are included in everyday objects. Our goal is to motivate social and *musical co-creation* for families with disabled children to improve their health and quality of life. To extend our design thinking, practice and understanding of a design's value, meaning and empowering potential, we build on a humanistic health approach, resource-oriented thinking, Positive psychology and Empowerment philosophy. In the paper we present and discuss *how we design* cross-media, interactive, tangible and musical things to motivate and empower a variety of users in our on-going RHYME project.

## **Keywords**

Universal Design, Tangible Interaction, Musical interaction, Multi-sensory environment, Empowerment, Resource-Oriented

## Introduction

The seven principles of Universal Design, like "4. Perceptible Information" and "5. Tolerance for errors" is formulated from the design's or system's perspective. The principles focus on the qualities of the system or design, not on the value of use, or the long time experience and use of many people. In this paper we will argue that this narrow system or product design perspective overlook important aspects of design like the diversity of the users and uses, but also of the *value* and *culture* of designs and things. By broadening the perspective and focus on users' diversity, long time experience of many users and use, we will argue that it will change our way of "designing for all". Things and technology might empower or disempower the user depending on the designs thoroughness and use in the situation and over time.



Figure 1: Family Musicking in Wave Carpet

Designing empowering things is much more demanding than what "Intuitive Use", "Perceptible Information" and "Tolerance for Error" express, because it demands a deeper understanding of *why* and *how* we use and relate to things over time, insight in the *value* and *culture* of designs and things from knowledge fields like sociology, social anthropology and health related fields.

In this paper we argue based on practical Research by Design cases from our ongoing research project RHYME [29]. Our project goal is to create tangible interactive multimedia things that motivate families with disabled children to co-create together. We build on a humanistic health approach, and use Resource-Oriented thinking, Positive psychology and empowerment philosophy to expand our design thinking and practice. Our design field, Tangible Interaction [25], where computer capabilities is included in everyday objects is a fast developing design discipline and is of great importance for the Universal Design field [7]. It is closely related to fields like Assistive Technology [7], and combines both physical aspects, typically designed by industrial designers, with interface design, typically designed by interaction designers. It is a challenging area for Universal Design because *it can* and *should not* be divided into hardware and software, because it is the combination and hybridisation that represent unique possibilities for the Universal

Design community. Tangible Interaction Design represents sensorial, narrative and social possibilities by its hybridisation of hardware such as materials, structures and sensors and software that can remember, learn and respond intelligently. And that are networked to other cultures and communities of things and people through the Internet. These possibilities are easily overlooked if we divide the design challenge into physical industrial “shell design” and the interface software design, and leave out the service design dimensions.

Working with physical interactive technology we also build on an actorial understanding of technology inspired by sociologist Bruno Latour, and his hybrid understanding of the relation between people and technology [16]. Latour points out that things and technology are not only tools with functions for specific predefined tasks as Heidegger and his followers focus on [15], but rather complex mediators of power and meaning [16]. Empowerment philosophy developed on the same ground as Universal Design, the human rights movement, where participation and equality is common ground [20]. Resource-oriented thinking has learned us to focus on people’s abilities not on their diagnosis, weaknesses and special needs [2, 22]. Things that have the goal to empower should not only “tolerate errors” as the 5<sup>th</sup> UD Principle demands, but provide the users with positive challenging experiences. Further it should make the user able to develop his knowledge and capabilities to act and master over time. Empowerment thinking also emphasises the right to participate and build equal social relations over time. So empowering things should offer the users the ability to create, collaborate and strengthen relationships. Here the hybrid thing, the Tangible Interaction Designs, that combines cultural things with network and computer capabilities (also called Internet of Things), offers new and exciting possibilities for empowerment in the Universal Design community as we have discussed in earlier papers [4, 7].

The paper is structured in the following way: First we present the approaches we consider relevant in order to expand the design perspective. Secondly we present the RHYME project, its goals and methods. We present 3 cases and generations of designs in our project, and because of the limited space here, *some* examples of how we reason and design to make them empowering for diverse users. Lastly we summarise the current stage of the project and our design suggestions pointing towards an Empowering Tangible Interaction Design for Diversity.

## **Extending the Perspective**

### **What is a Designed Interactive Thing?**

Things are not only physical objects with shape that offers and affords functionality or beauty. Things also structure actions, relations and are defined by and define the user mutually by the cultural and genre competence the user possesses, like social anthropologist Appadurai points out in his book “The social life of things” [1]. Things are also complex mediators of meaning, relations, actions and power that sociologist Bruno Latour has shown in his work within sociology and technology [16]. His work has been of great importance for the HCI and Interaction Design fields, in particular his Actor Network Theory and theory of mediation [16]. Latour shows how things can act, not only as neutral objects or tools, but as active actors, or *actants*, as he calls them, with abilities to influence scientific results and everyday life. So based on this insight we should take all these perspectives into consideration when designing, not only focus on shape and

use of a single isolated thing, like industrial designers often do. Service Design usually takes into account experiences that develop over time, but seldom the cultural perspective and consequence of their design. Their business oriented background and goal, seldom focus on the *consequences on ethical value*, meaning and power structures the design creates and maintain, but rather on the market potential and return on investment. But like Latour points out we negotiate meaning and relation through use of things [16]. Again, things are *not only* efficient and functional tools like Heidegger and his followers focus on [15].

### **Expanding the Role of the Thing**

In an earlier paper we have discussed how tangible interactive things containing both materials such as textile, computer components like sensors and speakers controlled by “intelligent” software, have many more layers of possibilities than physical things and computers isolated [4]. They can be programmed to react immediately and strongly on a weak action, like an electronic instrument, and just therefore offers great possibilities for the Universal Design community [7, 18, 19]. But the interactive things can also be programmed to answer intelligently and delayed like a human being in a communication situation, in a close by or in another room, just to give an example. Computers can be programmed to listen, learn and remember, and here lies great empowering possibilities for the Universal Design community and Assistive Technology [7]. Interactive things can be programmed for instance to motivate interaction, stimulate initiative, development of mastery and social interaction [4].

### **Empowerment thinking, Positive psychology and Resource-Orientation**

The Empowerment concept and thinking grew out of the civil rights movement in the 1960s-1970s, and is connected to political, democratic and humanistic values [20], the same ground that the field of Universal Design is grounded on. In psychology, empowerment is related to preventive thinking, which is anti-medical and anti-psychiatric [7]. The focus is on self-actualisation, concentrating on the abilities and strengths of the person, not on their diagnosis or weaknesses. The goal is to improve vitality, self-esteem, social relationships and participation, through mutual and equal, positive relation building experiences [7, 18, 19]. Empowerment is always situated in a context, and is happening and unfolding in culture, where every situation is different.

From resource-oriented thinking we have learned to focus on peoples abilities, not on their diseases, weaknesses or special needs [2, 22]. From Positive psychology we know that stimulation of positive experiences motivate interaction [24], while failing ends up with demotivation and fatigue [19].

### **The relational concept of Musicking**

Within music the famous musicologist and composer Christopher Small has developed the concept of “musicking”, which is a very interesting concept for design. With the word “musicking” Small moves music from being an Art Work to an equal *meaning making* and relation building *activity*. Play, listen, sing, dance, clap and shake are for Small equal meaning making and relation building activities, where one expresses one’s identity in and with music and music related activities in everyday situation. This concept has been used by health related fields like Music Therapy. Interesting from a design point of view is that Small incorporates both the power structures of the architecture of the concert hall, but also the whole service journey as part of the musical meaning

making activity, and how physical and virtual “touch points” maintain and produce meaning and culture.

### **Designing for Musicking**

In the humanist health approach we build on health as an experience of wellbeing rather than cure from illness [2]. Music in an empowering health context, then becomes a resource for health promotion. The music therapist and researcher Randi Rolvsjord has thoroughly presented and argued for a resource and empowerment oriented perspective in Music Therapy [21, 22]. The focus is on the abilities and strengths of the person, not on their diagnosis or weaknesses. The goal is to improve vitality, self-esteem, social relationships and participation through mutual and equal, positive relation building musical experiences [23]. To design empowering tangible interaction designs with such goals, the challenges shift from the interface design and Universal Design principles' perspective, to the *relation building potentialities* of the interactive things. The focus shifts from controlling the interface to motivate social interaction, co-creation and “musicking” [26]. Tangible interaction designs that motivate “Musicking” between people with different competencies, abilities and motivations to interact and communicate together *on equal terms*. To achieve our health goals the interactive things must *evoke positive feelings*, be able to *master* and be *challenging over time*, create and strengthen *social relations* and offer a *shared* experience of meaning.

### **The extended Design Challenge**

When designing, and specially when designing for people with special needs, we have to take all this knowledge and these perspectives into consideration when designing: How does the thing we design mediate the negotiation of meaning, actions and relations? Does the designed thing open up for negotiation, or does it give one user the right to define what it is or how it should be used? Does it invite to many ways to use it and relate to it? Or does it encourage a “right” way to use it, for instance described in the user handbook, the way the designer has decided to use it right. By describing a way to use it in a user hand book the designer takes the role to define the *right* way to use it, and thereby other uses to be secondary or wrong. The designer thereby sets herself in the position to define what is right. This definition power as we have learned from Michel Foucault [13] is an important power position we have to understand the consequence of. Do we want to promote this power position and is it in line with empowerment and resource-oriented thinking? We will argue that the answer is no. How the designed thing structures actions, choices, relations and power in a Foucauldian sense, is something we as designers have to take deeply into consideration when designing and acknowledging diversity. Consciously rejecting words like *Universal* and *Inclusive*, because of the insight in the definition of power. Focus on the persons strengths and abilities, not their special needs, weaknesses and diagnosis the designed thing has to offer: many positive experiences, no wrongs or failing, many ways to vitality and self-expression, the ability to act and build competence (mastering), many ways to strengthen mutual social relations, diverse ways to share and participate and create meaning to be empowering. In the following we will present some practical examples of how we try to answer this design challenge.

## **The RHYME project**

### **Background and Goal**

The framework and basis for this paper is our ongoing RHYME project, financed by The Research Council of Norway through the VERDIKT programme [29]. The project is a multidisciplinary project between the Centre for Music and Health at the Norwegian Academy of Music, the Institute of Design at Oslo School of Architecture and Design (AHO) and the Institute of Informatics at the University of Oslo. The goal of the RHYME project is to improve health and life quality for persons with severe disabilities, with the use of tangible and musical interactive things: These interactive things are computer based, networked and multimodal things, which communicate following musical, narrative and communicative principles. They are interactive, social, intelligent things that motivate people to play, communicate and co-create, and thereby hopefully reduce passivity and isolation, and strengthen health and well-being.

Through the five years (2010-2015) the project will last we will develop new generations of tangible interactive things every year focusing on different user situations. The first year we started testing an older installation [28] to create a common ground in the project. The second year and generation we worked with all thinkable multimedia possibilities and wired solutions. The third year and generation we focused on mobile technology with the limitation wireless and current battery possibilities offered. The last year we will build social media solutions and distributed solutions connecting interaction between different places such as at home and on the street, or between homes. [29]

### **Method – Multidisciplinary, Research-by-Design and Action oriented**

The RHYME project is multidisciplinary, joining competences from Music Therapy, Music and Health, Psychology, Industrial Design, Interaction Design, Musicology, Music Composition, Computer Science and Universal Design.

Our design research methodology is user-centered and practice based, where we develop knowledge through design of new generations of interactive things discussed in earlier papers [3, 27]. Our user studies are action oriented and multidisciplinary. We work together with 5 families that test, discuss and suggest solutions and changes. During the test period we make changes based on our observations and discussions in the project and with focus group members. During 2<sup>nd</sup> Generation we observed 5 children interacting together with their care persons. We made 4 different actions over a period of 1 month at a school for children with special needs. From one action to the other, we made changes based on the previous action, weekly user surveys, observations and multidisciplinary discussions. All sessions were video recorded from three angles to get as rich material and understanding as possible. From the last mobile 3<sup>rd</sup> Generation of interactive things was tested by the five children's families, including grand parents and siblings.

### **1<sup>st</sup> Generation – ORFI**

The first empirical study in the RHYME project was of the ORFI installation (Fig. 2), created earlier by three project members [28]. ORFI consists of 20 pyramid shaped soft modules and a dynamic video wall. The modules are made in black textile and come in three different sizes from 30 to 90 centimetres. Most of the soft black pyramids, the ORFI modules, have orange origami shaped "wings" mounted with an orange transparent light stick along one side. The "wings" contain bendable sensors. By

interacting with the wings the user creates changes in light, video and music. Two orange modules contain microphones. The black wing-less modules contain speakers.

### **ORFI – Empowering Design Choices**

ORFI is shaped as a hybrid, a hybrid between furniture, an instrument and a toy, in order to motivate *different interpretations, interaction forms, activity levels and relations* [4]. One can sit down in it as in a chair or play on it as on an instrument, with immediate response to interaction. Or one can talk, sing and play with it, as with a friend and a co-musician in a communicative way, where ORFI answers vary musically after some time, what we call shifted response [5]. Every module contains a micro computer and a radio device, so they can communicate wirelessly with each other. The modules can be connected together in a Lego-like manner into large interactive landscapes, both as a possibility for self expression and to mediate different interaction forms (interior design, sleeping to sound). Or, the modules can be spread out in a radius of 100 meters. So one can interact with each other sitting close or far away from each other. There is no central point in the installation, instead it is like a field [8] of many potentialities. The users can look at each other or at the dynamic video they create together. Or one can just chill out and feel the vibrations from the music sitting in the largest modules as an immersive, ambient, experience. There are many ways to interact, focus and gain sensorial stimulating positive experiences. The ORFI installation contains 8 different genres of music and related dynamic video tapestry to choose between from more traditional Jazz, Funk, Noise to Disco, Classic music, Film sounds and possibility to create your own music with your voice and change and play with it in the ORFI landscape. So there are many ways to *express one self and develop social relations* in ORFI. But also develop relations to ORFI itself: competence in playing a genre, different ways to create the physical landscape or tag the modules physically in order to personalise ORFI. Just to mention three examples. Shape-vice ORFI's pyramid shape is open to many interpretations, from being a traditional pillow, a birdlike toy, a boat with sails, to an instrument to control with high precision, or just a modular soft landscape to rest on and with. Every corner of the pyramid has a rubber hook to be buildable as building blocks.

### **Observations, Findings and New Challenges for Generation 2**

In our many observations of ORFI we have seen very many ways to interact with and in ORFI described in earlier papers [4, 6, 7]. Some treat ORFI like an electronic instrument to perform advanced sound synthesis, some use it for pillow war and treat and talk about it as a toy. The many music genres to choose between becomes an important source to chose, decide and perform power and self regulation [23]. We observe over and over again how softer music is chosen after some time with louder and faster music types. From our action oriented, multidisciplinary user study we found several weaknesses with ORFI, and many desired qualities, that we wanted for a new generation of interactive things; In particular the music therapists and music and health professionals wanted the sound source to be close to the interaction place, similar to how acoustic instruments work. Equally, we wanted a closer relation between the interaction place (sensor) and the light output. For interactive objects, it means to place the input sensor close to the speaker. This is a complex design challenge regarding wireless objects, object size and weight, sensor qualities, sound quality and wireless sound transmission. We also wanted to explore more sensory stimulation like vibrators and stronger speakers, and create

more easily enabled input sensors. Finally we wanted to be able to integrate microphone, speakers and camera for new cross-media interaction possibilities.

## **2<sup>rd</sup> Generation – Wave**

As an answer to the described challenges we created the Wave Carpet (see Fig 1). It is a seven-branched carpet of the size 3.5 x 3.8 meters. Two branches or “arms” contain digital bend sensors. Two “arms” contain accelerometers, which register movement in three directions. One “arm”, in the middle, contains a microphone, and the last two contain projector and web camera. All arms have orange velvet tops that light up during interaction. To activate the camera and projector, the user holds on the orange, soft, velvet touch sensors, and the light on the microphone lights up, reacting to the sound level, and records when activated by relatively higher sounds. The carpet is filled with different kinds of fill that gives it a “landscape” structure. The carpet “body” contains speakers, vibrator, camera, pico projector and computer. It doesn’t run on battery power since it is connected to a wall socket [29].

### **Wave – Empowering Design Choices**

To offer empowering qualities in Wave we made a lot of design choices that in several ways differ from traditional functionalistic and “less is more” design ideals. We wanted to offer many different ways to interact and get positive experiences for diverse users; One can sit or lie on it and just experience the musical vibration of the speakers and strong vibrator. One can sit opposite each other and operate it like a game control device. Or just concentrate on one arm and develop competence. For instance, just move the accelerator arm in any way, play on the two synthetic voices with the arms containing bend sensors, or use the microphone and play back the recorded input dynamically with the accelerometers. Or one can use the camera to capture the players, use the camera and microphone, interact socially with two microphones and projecting what the camera records, just to explain some possibilities to play alone, develop competence to play with mastery and co-create with others [29].

### **Observations, Findings and New Challenges for Generation 3**

During the test period we observed that users interpreted and explored the carpet in very different ways. We have earlier presented these in more detail [3]. Here we will only summarise some of our findings. The most important was that we observed very diverse use of the Wave carpet. Some sat on it gently and treated it like a creature and often talked about it as an octopus. Others jumped around on it and treated it as a trampoline. Some were inspired by interaction with the camera in one arm, and projected on the wall by holding the other arm containing the pico projector. Many were occupied by talking to the microphone and letting the carpet answer in a turn-taking manner. And others just relaxed and felt the vibration onto the body.

## **3<sup>rd</sup> Generation – Reflect**

Reflect is the name of the 3<sup>rd</sup> Generation of interactive things. The current version consists of two mobile interactive things containing a computer (iPod Touch), sensors (bend and touch), speakers, LEDs and a RFID reader. One thing is shaped as an abstract creature with a “head” and “trunk” or like a soft banjo with body and a long neck (see Fig 3). The “trunk” or “neck” contains the RFID reader and a bend sensor, while the head or body contains most of the lights and sensors. Further, Reflect includes a system



of RFID-tags that is connected to different common and more abstract things, like slippers to wear, kitchen pots, tools and music instruments to use or play on and toys to play with. Further there are more abstract objects like furry balls to cuddle and smell to evoke arousal and expand the sensorial experience. Currently we have around 100 different things with RFID tags to play on and with by using one of the Reflect tangibles. They all play differently relating to what *Scene* the user has chosen with the RFID reader. We currently have 8 different *Scenes* such as ABBA's Mamma Mia, and we continuously create new ones [29].

### **Reflect – Empowering Design Choices**

The Shape and physical design of Reflect designed to be as ambiguous as possible to open up for many interpretations, interaction forms and ways to relate. To offer the user many positive experiences we use several media (light, sound, tactility), structures (round soft head sized and grip sized long bouncing “trunk”), materials (contrasting textile such as white silk, yellow velvet and black wool) and responses, both direct and shifted [5]. To offer many ways for self-expression we use several media, many ways to relate (e.g. playing on and sleeping with), many tagged objects to choose and *Scenes* to express and self-regulate emotions with, and narrative music paths to follow, just to give some examples of how we designed Reflect to motivate co-creation and to empower.

### **Observations, Findings and New Challenges for Generation 4**

During the test period of Reflect there were many family constellations that joined the test. Some for example came with the father and grandmother on one occasion, and father and siblings on another. We observed many interaction forms, intensity levels and use sequences that varied over the hour they played with Reflect every time. One girl used the Reflect creature both like a tool to activate the RFID tags connected to all the objects, just to see what and how they sang. Later during the test she used Reflect as a sleeping and glowing companion, as a guitar to hang over her head and play on, as a stretching fitness machine and as a co-musician. Many of the children talked into Reflect's trunk, expecting it to be a microphone there, since both Wave and ORFI had microphones (the reason for not including a microphone this time was technical only). The many RFID tagged objects made the children explore in many ways both musically by developing a complex musical choir, physically by the differences in shape, material and ways to interact with them in diverse ways and socially by engaging the whole family in various ways. The earlier mentioned girl showed her grandmother how to interact with the trunk to make the different things sing together, while the father played on the maracas drum activating the RFID tag to add an electronic maracas sound to his own drumming. The tagged things were used for wondering about what it had to say or sing, but also in a traditional manner as mentioned with the drum. But they were also used to develop mastery in pace by speedy activation of the tags to develop the music faster and thereby develop musical competence. The children very fast became surprisingly competent to handle the most of the basic possibilities and very fast took on the role of teaching the rest of their family, a role they didn't get to have very often.



Figure 2: Father and Girl in ORFI



Figure 3: Man interacting with Reflect

## Conclusion – Empowering Qualities and Design for Diversity

Our goal with this paper is to contribute to the field of Tangible Interaction Design related to Universal Design and Inclusive Design challenges with our perspectives and practical experience from the field. By focusing on the empowering potential of interactive things when designing, we have argued for a need to broaden our focus compared to the narrow product design perspective the Universal Design principles represent. As we have a goal to empower our users we have to incorporate a deeper understanding of how things mediate social and cultural meanings, actions, our narratives and relations for diverse users over time. Based on this goal we have presented and argued with practical design examples from an on-going research project for design qualities interactive things should have to be empowering. We have presented several examples of such design qualities to argue for our view. We have suggested that tangible interaction design should have the following qualities to be empowering. The tangible Interaction Design should *offer the users*:

- **Many roles to take, interpretations to make** of the design, and the design must be consistent with its character to create adequate expectations.
- **Many positive experiences** to make in every situation, where there are *no wrong actions* or failing possibilities, where there are few dependencies and no closed paths and there are many ways to experience vitality and self-expression.
- **Many ways to act and build competence and mastering in every situation** based on the role and the interpretation the user take and make. So there have to be many paths to take, many sequences to perform and many narratives to build, therefore it should have few dependencies in sequences.
- **Many ways to develop and build relations** to things, people, actions (e.g. mastering) and experiences (expectation based on narrative structures and competence). In other words many ways to share, relate, participate and create meaning over time.

These design qualities' ideals point towards an ambiguous, open and relation oriented design, where there are multiple possible relations to physical, visual, spatial, temporal and role based relations the user can choose and realise through use (improvisation) in every situation. In our opinion these design demands expand the perspective of the Universal Design principles with a more complex understanding of the relation between people and design.

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