Changing Perspective: A Co-Design Approach to Explore Future Possibilities of Divergent Hearing

Judith Dörrenbächer
Ubiquitous Design
University of Siegen
Siegen, Germany
judith.doerrenbaecher@uni-siegen.de

Marc Hassenzahl
Ubiquitous Design
University of Siegen
Siegen, Germany
marc.hassenzahl@uni-siegen.de

ABSTRACT

Conventional hearing aids frame hearing impairment almost exclusively as a problem. In the present paper, we took an alternative approach by focusing on *positive* future possibilities of 'divergent hearing'. To this end, we developed a method to speculate simultaneously about not-yet-experienced positive meanings *and* not-yet-existing technology. First, we gathered already existing activities in which divergent hearing was experienced as an advantage rather than as a burden. These activities were then condensed into 'Prompts of Positive Possibilities' (PPP), such as "Creating a shelter to feel safe in". In performative sessions, participants were given these PPPs and 'Open Probes' to enact novel everyday activities. This led to 26 possible meanings and according devices, such as "Being able to listen back into the past with a rewinder". The paper provides valuable insights into the interests and expectations of people with divergent hearing as well as a methodological contribution to a possibility-driven design.

CCS CONCEPTS

• Human-centered computing → **Interaction design process and methods**

KEYWORDS

possibility-driven design; positive design; performative methods; participation; enhancement; hearing impairment

CHI 2019, May 4–9, 2019, Glasgow, Scotland UK

ACM ISBN 978-1-4503-5970-2/19/05...$15.00
https://doi.org/10.1145/3290605.3300259

ACM Reference format:
Judith Dörrenbächer and Marc Hassenzahl. 2019. Changing Perspective: A Co-Design Approach to Explore Future Possibilities of Divergent Hearing. In *2019 CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), May 4–9, 2019, Glasgow, Scotland, UK.* ACM, NY, NY, USA, Paper 29, 12 pages. https://doi.org/10.1145/3290605.3300259

1 INTRODUCTION

Typically, hearing aids are thought of as prostheses to compensate a deficiency. Their purpose is to repair impaired hearing and at best to restore 'normality'. However, recent research argues this to be a limited perspective [12,27,29]. For example, Kjeldsen and Matthews criticize that conventional hearing aids are mainly solutions to a sound delivery problem. This is "a response to one particular problematisation of hearing" ([29], p. 532), which ignores other potential problematizations. Based on this, research gradually leaves the audiological lab, no longer restricting itself to audiograms and loss curves. Instead, hearing impairment becomes increasingly considered as a 'communication disability' involving at least two people: the listener *and* the speaker. Studies begin to include social, psychological and contextual aspects [12,27]. The focus is on social interaction *per se* and not merely on the person with the hearing impairment. Behavioral patterns in everyday life, noisy settings and misunderstandings with friends, family, colleagues and doctors become included [18,26,36].

While research on hearing impairment broadens its view [13,14], it still frames impaired hearing primarily as a problem. In typical studies, participants are asked to speak about problematic hearing scenarios and to compare their hearing to 'normal' hearing [29]. However, by focusing solely on problems and on a particular 'normality', one may overlook potential benefits of what we suggest to call 'divergent hearing'. Thus, in the present paper we intend to go a step further by exploring potential *positive* sides of divergent hearing to inspire unconventional hearing technologies.

To do so, however, is a methodological challenge. Design approaches that particularly focus on the positive, i.e., possibility-driven design [7–10,20], usually investigate

activities that already exist to better understand the origin of enjoyment and meaning. However, any positive activity of divergent hearing identified through this is at least in part a consequence of the possibilities and limitations of already existing hearing technology. To envision future possibilities requires to *simultaneously* think about not-yet-experienced meanings and not-yet-developed technologies, which constitute each other. While Human-Computer Interaction (HCI) increasingly focuses on methods to speculate about consequences of future technologies [11,15,32,33], participant-driven research into future activities, which especially focuses on the positive, that is, on possibilities rather than problems, seems far from settled methodologically.

Consequently, the present paper's objective is twofold. On the one hand, we explore and present yet-to-be-imagined activities, which will enrich the lives of people with divergent hearing. The overarching goal is to inspire the design of unconventional hearing technologies. On the other hand, we present and discuss a novel methodology explicitly developed to explore positive activities in a possibility-driven co-design process.

We will start with a brief summary of existing debates around the notion of human enhancement and prostheses. We then present our theoretical approach to address those debates in HCI and Interaction Design. Based on this, we developed a performative method and employed it to explore the possibilities of divergent hearing in the form of anecdotal future positive activities. Finally, we will present and discuss our findings about future hearing as well as our methodological contribution.

2 ENHANCING OR REPAIRING?

Obviously, when it comes to the human body, it is very challenging to determine what is 'normal' and what is 'non-normal', or what is natural and what is artificial. We are used to manage and augment our body with exercise, diets, medicines and, of course, with technology. An example of typical debates is the ongoing discourse on enhancements in sports. It is indeed difficult to argue why an athlete is allowed to wear contact lenses to compensate a visual impairment, but not to take anabolic steroids, if her body produces less than the bodies of others. Especially when it comes to prostheses, this territory becomes tricky. The case of Oscar Pistorius was a paradigmatic one [7,19]. He is a runner with both lower legs being amputated. He uses custom-designed carbon-fiber prostheses, earning him the nick name "The Blade Runner". In 2008, Pistorius applied to the Olympic Games and was banned at first, because consultants claimed the prostheses would provide him with unfair advantages over 'normal' runners. This is an example, where designers understood 'non-normality' as a *possibility.* They explored technology to create a new, enhanced type of leg *and* runner. In the context of HCI in general, as well as hearing aids specifically, such a possibility-driven perspective does not feature strongly. Manufacturers of hearing aids (in the widest sense) only recently started to develop products, which enhance by, for example, filtering noise or translating language [25].

2.1 Pessimistic versus Optimistic View on Enhancements

The lack of a possibility-driven approach is at least in part due to two opposing positions in debates about technological enhancement. Some emphasize the fear of losing control over the technology [1]. This fear is related to concerns of losing skills or becoming other-directed by one's own prostheses [30]. Others understand technology as a way to transcend given limitations, even to transcend humanness itself [31]. Both perspectives have a longstanding tradition in the philosophy of technology as well as in utopian and dystopian visions of potential futures popularized through many movies and books.

However, both positions are based on the idea of the insufficient human, a notion deeply embedded in western culture. Particularly at the end of the 19th century, philosophers, psychologists and anthropologists considered human beings as incomplete [16], leading the anthropologist Arnold Gehlen in 1940 to coin the term "Mängelwesen" (deficient being) [17]. To survive, these "Mängelwesen" require the support of artifacts ranging from clothes to computers. Nowadays, this understanding appears outdated [21]. There is no such thing as a primordially all-natural human being, which fell from grace and from then on had to rely on technology [24]. Human beings are what they are *because* of technology. HCI is – by referring to Actor-Network Theory or New Materialism – increasingly dealing with notions of shared agency and entanglements, where technology and humans constitute rather than compensate each other [38,40].

2.2 Intra-activity

According to philosopher and physicist Karen Barad, there are no preexisting, separate elements that now and then interact with each other. Instead, everything emerges through 'intra-action' in a relational process ([2], p. 33). Translating this to HCI: there is no human being that interacts with (or uses) technology. Human beings and technology exist and emerge together. It seems impossible to separate one from the other and potential boundaries between them are not as clear as often assumed [37]. Thus, when we enhance hearing, it does not necessarily mean we lose skills or become other-directed. We become different – but not necessarily better, since there is no predefined notion of an optimal hearing. Of course, there are better or worse solutions for specific situations and certain individuals. For example, for some people cochlear implants open doors to the world of spoken language and to fulfilling

relationships with other people. For others, they lead to the exact opposite. They alienate from their previous deaf community, where the mother tongue is sign language – a unique form of expression that is feared to become extinct. In this example, repairing actually leads to a socially less desirable situation. Since the shared agency of human beings and technology is always situated [19], it is important to deal carefully with potential entanglements, keeping the consequences of new technologies in view for its users and aiming to envision situations, where consequences are positive.

2.3 Possibility-Driven Design

The notion of allowing positive dialogue among designers, users, materials and situations to explore the possibilities technology could provide, is at the heart of approaches of a possibility-driven design [7], such as Experience Design, Positive Design and Design for Wellbeing [8–10,20]. These are based on positive psychology [35] and – among other claims – call for an alternative to an exclusively problem-driven approach. Problem-driven approaches start with a presumed problem in need to be solved and focus on avoiding or neutralizing the negative. For example, impaired hearing is a problem, potentially solved through a hearing aid. An alternative to this is a possibility-driven approach. It frames artifacts as possibilities for enrichment and as potential sources for new activities and meaningful experiences. For example, clothes do not only protect human bodies, but allow for self-expression, dissociation, bodily transformation or exciting variations of identity. A possibility-driven approach focuses on emerging human experiences rather than technology. It acknowledges the powers of artifacts to constitute humanness itself and focuses on harnessing these powers to enrich people's lives based on a proper understanding of what matters to them.

3 A POSSIBILITY-DRIVEN APPROACH TO POSITIVE FUTURE ACTIVITIES INVOLVING DIVERGENT HEARING

Based on the theoretical work outlined above, we conducted an exploration into potential positive future activities for people with divergent hearing. The goal was to provide insights to stimulate the development of unconventional hearing technologies. Instead of posing the question of "How to make impaired hearing as 'normal' as possible?" we posed the question of "How to enrich the lives of individuals with divergent hearing through technology?" As already pointed out, HCI provides no readily available method to speculate with lay people in detail about positive future meanings *and* novel devices simultaneously. To this end, we developed a new method to gather the insights, we felt needed to inspire the design of positive hearing technologies.

Our study consisted of two steps. In the first step, we explored *current* positive activities of divergent hearing through a particular form of interview. The second part took the positive activities gathered in step 1 as starting points and used a performative approach to co-create detailed enriching *future* activities around divergent hearing.

Table 1: Participants.

	Gender /Birth	Occupation	Aids	History	Loss	In Step	
						1	2
P1	m/1950	Book Shop Owner (retired)	BTE	loss since 2000, aided since 2006	moderate	X	
P2	m/1989	PhD Student	BTE & one-sided CI	loss since birth, aided since 1992, CI since 2007	profound	X	X
P3	m/1938	Medical Engineer (retired)	BTE	loss since 1960ies, aided since 1995	severe	X	
P4	m/1938	Product Manager (retired)	BTE & one-sided CI	loss and aided since childhood, CI since 2015	moderate left: profound	X	X
P5	m/1943	Teacher (retired)	BTE	loss since 1990ies, aided since 1995	moderate right: severe	X	X
P6	f/1974	Caregiver in Home Care, Homekeeper	ITE	loss since birth, aided since 1993	moderate to profound	X	X
P7	f/1946	Accountant (retired)	BTE	loss since 1986, aided since 2005	moderate	X	
P8	f/1951	Post Office Clerk (retired)	BTE	loss since 1990ies, aided since 2017	moderate left: severe	X	X
P9	f/1968	Caregiver in Home Care	BTE	loss since 1998, aided since 1998	moderate	X	X
P10	f/1944	Employee Chamber of Agriculture (retired)	BTE	hearing loss since 1960ies, aided since 2011	moderate	X	X

Ten individuals participated in step 1 (5 female, 5 male, median age=63, min=28, max=79). Seven of them (4 female, 3 male, median age=59, min=29, max=80) were invited to step 2. They were recruited with the help of Hörzentrum Oldenburg GmbH, an audiology research organization. They were compensated with 12€ per hour. Each participant provided a written permission to publish pictures taken during the process.

Participants had diverse backgrounds and occupations (Table 1). Most of them were retired, but there were also younger individuals employed or in academic training. All had different hearing abilities – some were born with a divergent way of hearing, others had an age-related hearing

loss. All of them used a variety of different hearing aids. The majority had behind-the-ear hearing aids (BTE), one person used in-the-ear hearing aids (ITE) and two individuals used cochlear implants (CI). Thus, all of them were used to at least two ways of hearing: with and without hearing aid. In addition, most of the interviewees had already tested a number of different hearing aids. Consequently, they were used to pay attention to perception and to the many roles hearing plays in our life. They can, thus, be considered 'experts' for divergent hearing.

3.1 Step 1: Interviews About Current Positive Activities

3.1.1 Method. For step 1, we conducted semi-structured interviews. We first encouraged participants to focus on their very personal way of hearing by replacing the notion of 'normal' and 'non-normal' hearing with the notion of diverse ways of hearing, each with its own advantages and disadvantages. We then facilitated the conversation about the positive aspects of their particular hearing through questions, such as "In which situations do you benefit from your way of hearing in comparison to other people?", "Does your particular hearing create something positive in your life?", "Is it crucial to your personality?" or "Did you acquire positive skills or attitudes through your particular hearing?" On average, the interviews lasted 90 minutes. Each was audio recorded and later transcribed. We used thematic analysis to structure the content [3]. After familiarizing ourselves with the transcripts, we divided the content into meaningful units for further analysis (e.g., one or two sentences describing a particular issue). We then sorted these units according to similarity. Several themes emerged, which were discussed and finally consolidated.

3.1.2 Findings. All participants enjoyed taking off the hearing aids from time to time, since in some contexts, their personal unaided hearing provided a particular advantage. Most mentioned being able to sleep at night without any disturbance (P1, P2, P3, P7, P8, P9). Some stated to be better able to concentrate by taking off the hearing aids at work (P1, P2, P5). Time without hearing aids became also 'me-time', especially for people who led busy work or family lives. One participant explained: *"When I've been downtown, in the shops, it is often very noisy: the beeping of the cash till, the buzzing of the freezer. At days when I am stressed out, I notice this much more than on other days and it really gets on my nerves. When I come home, zap – I take the things [aids] out – finally calmness"* (P9). Another person emphasized quiet time for herself in the morning (P6).

Some participants enjoyed manipulating their hearing with the hearing aid itself, for example, with programs, *"with the music program, I have a better music experience; even better than before I had the hearing loss and got aids"* (P1), or by controlling the volume, *"in church, the awful singing gets on my nerves, but I can just turn down the device"* (P3).

In social contexts the advantage of avoiding conflicts was a prevalent topic – being able to spend time next to each other in spite of having different interests, e.g. reading a book while the partner is watching TV or while the children are listening to loud music (P3, P6, P9). Here divergent hearing became an ingredient of a more successful social life.

Even in conversations, divergent hearing was sometimes experienced as an advantage. Some participants explained that divergent hearing helps to be more attentive to particular people, because it simplifies choices: *"I focus much more on what is really interesting to me"* (P1), *"I choose people wisely. [ ] Especially at parties, people with loud voices are the best conversation partners, I know"* (P2). One person mentioned that he uses his hearing as an excuse: *"I am allowed to ask for repetition, when I did not get what was said. The hearing loss legitimizes me to do so. This can be very helpful when I did not understand something in terms of content. I use this mainly during conferences"* (P2). Other participants mentioned that the divergent hearing makes them more socially aware and that they developed more empathy for others (P2, P5, P9).

Quite contrary to conventional wisdom, four participants (P4, P5, P6, P9) emphasized that it does not matter to them whether their hearing aids are visible. Three (P4, P5, P9) even insisted on a future hearing aid to be visible. They came up with the topic by themselves and were very eager to talk about it. They said it is very important for others to know about divergent hearing. The reasons for letting others know are diverse. First of all, visible hearing aids can prevent misunderstandings. As one participant explained: *"Hearing aids could be bigger than they are right now. Advertisement caters for the vanity of people. But glasses are visible regardless and became fashionable accessories. You can show off hearing aids in the same way. And you can demonstrate: I want to be involved, I want to be part of you, I want to participate"* (P5). Thus, visible hearing aids help to prevent the impression of disinterest and can signal sympathy instead. Further, they prevent the false interpretation that one cannot grasp something intellectually: *"I want others to see them [aids]. I think it is easier. I don't want to hide it [divergent hearing]. Because when I ask for repetition or I give a weird answer, the other person can at least associate it with hearing loss and does not think 'Huh? What is wrong with her?!"* (P6). Besides visibility being crucial to successful communication, one participant mentioned that she is tired of hiding the thing that actually defines her. For her, a visible hearing device is a tool of emancipation – for example from parents, who did not accept the (visible) difference, when she grew up (P6). While her parents wanted her to be 'normal', the participant rather accepted being different and understood showing the aid as a statement of this acceptance. This

demonstrates that hearing aids can be vehicles to communicate pride and self-confidence. One person even mentioned hearing aids to be status symbols (P5). Another participant (P4), who recently got a cochlear implant, was very proud of his new abilities to sense the world differently. He managed to learn a new way of hearing even though he was almost 80 years old. He identified himself with the implant and called himself 'Cyberman'. The implant became a kind of motivational device for him – not only for learning a new way of sensing the world, but also for remaining up-to-date regarding technological development. And of course, he was proud to show off the technology and to make his new abilities visible to others.

3.2 Step 2: Enacting Future Positive Activities

In step 1 participants referred to particular positive experiences, they already made in everyday life. Obviously, these experiences are heavily grounded in and shaped by the design of existing hearing aids. In other words, the positive activities captured emerge from technology that has never been designed to create anything positive beyond restoring 'normal' hearing. For example, many of the positive experiences found in step 1 revolve around the fact that the hearing aid can be switched off or taken out. Without this function these positive activities would not have occurred. However, this function is the consequence of a technical necessity and was not deliberately designed to create the mentioned positive experiences.

In step 2 of the study, we aimed at tackling this problem. We wanted concrete and rich anecdotes of positive future activities grounded in everyday life, yet independent of technology and activities that already exist. Consequently, we needed to create situations in which we could observe lay people while performing yet-to-be-imagined meaningful activities with yet-to-be-developed technologies. To do so, we developed a performative co-design approach based on Barad's notions of 'intra-action'. 'Intra-action' urges to take a look at the dynamics in between elements instead of the elements as such. Thus, we aimed at looking simultaneously at all components of new activities in their interdependency. We were especially interested to see how possible meanings, technology and individual users co-constitute each other in future activities.

Obviously, involving lay people into design processes requires methodological support. Available methods either provide particular concrete technologies to explore potential activities and resulting meanings (e.g. technology probes [22]) or particular meanings to explore functionality and to shape technologies (e.g. invisible design [5]). Obviously, results are either heavily predetermined by given technologies or by given meanings. In the spirit of 'intra-action', however, we aimed at leaving both, technology and meaning, open, focusing on how both constitute each other. Consequently, we provided components able to inspire as well as to respond to each other – components that are rather sketchy and half-baked than well-defined and self-contained. More specifically, we developed and combined open outlines of potential meaning, so-called 'Prompts of Positive Possibilities' (PPP) and not-yet-specified outlines of technology, so-called 'Open Probes' (OP).

Table 2: Individual 'Prompts of Positive Possibilities' we extracted after analyzing the interviews.

	Prompts of Positive Possibilities (PPP)
P1	Being inspired by an unconventional way of hearing.
P2	Being able to sense acoustic information with other modalities.
P3	Feeling independent from hearing aids.
P4	Perceiving what the human ear usually cannot perceive and being motivated by this.
P5	Showing others that you pay attention to them.
P6	Allowing close people to disturb you.
P7	Being able to differentiate between different communication partners.
P8	Creating a shelter to feel safe in.
P9	Feeling independent from other people.
P10	Comprehending irony, emotional undertones and side notes.

'Prompts of Positive Possibilities' (PPP) were distilled from the interviews in step 1 (Table 2). They summarize the gist of the gathered positive experiences, independent of situation and technology. However, we did not only use the positive experiences of the participants, but also problems, which we transformed into positive statements. For example, we changed the statement "I don't like the way my hearing ability makes me dependent on my husband" to the PPP "Feeling independent from other people." Instead of focusing on the particular problem, the PPP opens up a space of possibilities. What kind of aid would allow for or even foster independence? Does it necessarily need to be an aid that changes hearing? In what kind of situations would I enjoy being independent?

For each participant, we extracted one PPP being specific to his or her individual interview (step 1). Examples are "Being inspired by an unconventional way of hearing", "Creating a shelter to feel safe in" or "Being able to sense acoustic information with other modalities". These deliberately abstract and ambiguous prompts were used to support the participants with imagining concrete future activities presumably able to fulfill the particular prompt. Through this, envisioned activities remain grounded in empirically gathered insights into experiences of divergent hearing, but at the same time invite to envision personally relevant activities.

'Open Probes' (OP) were objects custom-made out of a plain white fabric (Figure 1). They contained no technology (e.g., sensors), but were developed to provide opportunities for human action. Their shapes were derived from common wearables (brooch, belt, hood, scarf) since we were dealing with near-body technologies. In the same vein as with the PPPs, we simplified and alienated the shapes to foster ambiguity and openness instead of already inscribing definite ways of use.

Figure 1: 'Open Probes'.

In step 2 we then asked the participants to perform imaginary future activities able to fulfill a given PPP with the imaginary technologies provided through the OPs. To us, enactment and performance are key to fostering the process of the mutual constitution of the individual, potential technology and possible meaning. Instead of abstractly talking about futures, participants were prompted to immediately live through futures, setting time, place, and concrete interaction. This revealed crucial concerns, expectations and consequences.

All in all, our approach is related to several performative design methods, all aiming at speculation and ideation through enactment. On the one hand, it draws upon Bodystorming [6], one of the most popular methods, where designers ideate with the help of their body. On the other hand, it is related to User Enactments [33] and Speculative Enactments [15], where reality and fiction blend into performative experiments *with* participants. In addition, we included approaches that work with unspecified objects to imagine technologies, such as the so-called "Magic Tools" [4] developed for thinking in action by Brandt and Grunnet or the "Magic Thing" [23] of Iacuccui and Kuutti. The "bodyProps" of Wilde [39] share content-related attributes with our approach, since she creates open objects worn like prostheses to bring the participants' attention to their own bodies.

While we draw from those performative design approaches, we take a slightly different perspective. We focus on the positive and involve not only open material but also open positive meanings – the PPPs – to be further specified and defined through embodied play. Further, we are concerned with how the activities between people, material and meaning come into existence. None of the former approaches focused on this 'intra-active' becoming.

3.2.1 Method. Seven out of the 10 participants took part in step 2. We met the participants individually in a lab situation. The room was hardly furnished – some chairs, a table, an indoor plant. After an introduction, each participant received two cards. One of the cards featured their individual PPP distilled form her or his prior interview (e.g., "Being able to sense acoustic information with other modalities" for P2). The other card contained a random PPP from another participant. Participants were not informed about whether it had been 'their' PPP or not.

Each participant was asked to use the OPs to think of a (performance with a) novel device that would help him or her to respond to the given PPP. People were encouraged to set a scene, i.e., specify time, place and other people, and to play through this scene in detail, i.e., how they would act with the imaginary device in this situation. They were instructed to think aloud, while doing this. The facilitator (first author) took an active role in supporting the participant to further specify and to reflect the activity. Afterwards, we asked the participants to provide names to the imaginery devices just used. We then repeated the process with the second PPP. In general, we collected as many enactments with as many different imaginative devices as possible.

We spent on average 90 minutes with each participant. The enactments were audio and video recorded. We annotated each enactment separately. As a step of reflective analysis, we wrote short texts about how each imaginary device was used and what particular meaning had been created within the enacted activity. We then sorted these meanings according to similarity and created categories. In a second step, we focused on how PPPs, OPs and participants constituted each other in each enactment by writing short texts about how the agency evolved for each enactment.

In the following, we will first present and discuss substantial findings (i.e., the envisioned activities with corresponding meaning and material) and then discuss our methodological approach.

3.2.2 Substantial Findings: Emerging Future Activities. The study generated 26 future activities (Table 3). Each came into being through combining a PPP with an OP. As expected, the enactments led to novel activities by specifying the PPPs (ambiguous meaning) and the OPs (ambiguous material). Table 3 shows an overview.

Each activity is a unique anecdote and may serve as input to a later design process. For the present paper however, we wanted to further uncover common themes.

Table 3: Envisioned activities described through a specified meaning and specified material.

Specified Meaning	Specified Material
Being in control of the body orientation and the voice of a speaker with the...	**Bossy Rope**
Communicating that one did or did not comprehend what was said without having to say so with the..	**Brooch of Signals**
Being able to listen back into the past with the..	**Rewinder**
Showing others you pay attention to them with the..	**Ears of Animals**
Turning down voices from specific directions and informing others about the cancelation with the..	**Brooch of Silence**
Showing others that you appreciate what they are saying with the..	**Feedback Device**
Being provoked by others without having others to shout with the..	**Light Switch**
Being able to smell the location of a speaker with the	**Home Aiding Snake**
Being able to recognize the mood of a person at the telephone with the..	**All-Emotion-Telephone**
Being able to see what is happening at the back of one's head with the..	**Third Eye**
Being able to sense the identity of a person walking at one's back with the..	**Friendly Voodoo Doll**
Being able to bridge distance with the..	**Flying Hearing Aid**
Being roused by others without having others to shout with the..	**Provocateur**
Sensing anything that is approaching from behind with the..	**Alarm Leash**
Sensing the attributes (speed, danger) of what is approaching from behind with the..	**Vibration Cape**
Sensing danger during night at home with the..	**Vibrating Mattress Cover**
Being able to notice noises from animals in nature with the..	**Third Ear**
Sensing what is going on in one's body with the..	**Disease Detector**
Seeing what is coming from behind with the..	**Mirroring Glasses**
Sensing what is coming from behind with the..	**Bracelet of Signals**
Receiving information about objects with the..	**Info-Stethoscope**
Showing others you pay attention to them with the..	**Ear-Hood**
Becoming one with technology with the	**Completely-Implant**
Being able to record and share it with the..	**Recording Device**
Protecting one's thoughts and data with the..	**Data Protection Hood**
Being able to detect malfunction of one's implant with the..	**Magic Magnifying Glass**

Through similarity grouping, we found 11 activities to deal with the 'enhancement of social interaction' and 15 activities to deal with the 'enhancement of perceptional skills'.

Within the first category, we identified five subcategories. There was the aim of (1) '*communicating to others that they had not been understood*'. For example, a brooch provided a light signal as long as a listener could not understand a speaker. The device freed a person of permanently repeating the phrase "Pardon me". Only when the listener understood what was said, the light signal turned off. There were also four enactments about (2) '*communicating to others that one is listening or, on the contrary, that one does not want to listen*'. Because of the impoliteness of showing disinterest, one participant preferred her device to be for professional contexts only, for example, for guided city tours. A flying microphone device aimed at (3) '*focusing the speech of a selected person in a conversation*'. The device bridged distance by following a speaker and by amplifying his or her voice. Three hearing devices were about (4) '*allowing speakers to catch attention*'. These were created to prevent speakers from shouting. This is interesting, since these concepts are not targeted at the listeners with divergent hearing but could enhance other people, who want to communicate. An "All-Emotion-Telephone" addresses the subcategory of (5) '*allowing comprehension and empathy among dialogue partners*'. In the enactment, the device was able to enhance conversations especially for users of cochlear implants, who have trouble with perceiving the emotional undertone of spoken language.

The second category, '*enhancement of perception skills*', was defined by two main subcategories. The concepts of the first subcategory were in the widest sense (1) '*enhancing security*'. This subcategory comprised 10 devices. Most of them were about perceiving things behind the back of participants. We enacted, for example, glasses that mirrored the back and, thus, provided additional visual information. There was also a "Vibration-Cape" that translated different approaching items – from pedestrians to cars – into vibration signals onto the back of the participant.

Enhancing security meant something completely different to a participant using a cochlear implant. He was worried about privacy and enacted a scenario with a "Data Protection Hood". For gaining control over his implant, he used a device that allowed him to peep into his body. Some concepts about security included a lot of playfulness and were less fear-driven. For example a participant dragging a 50m long "Alarm Leash" behind herself during walks, was very much amused about the strange appearance of her new device. A device called "Friendly Voodoo Doll", intended to be used at work, allowed to feel safe but also to lighten up the mood. We enacted a scenario where the participant was sitting with his back to the door of his office. He had the doll placed on his desk. Each time when someone walked the hall, the doll simulated the way of walking of the specific person in the hall. Thus, there was no unwanted surprise when someone suddenly stood next to the participant. We speculated whether the doll would lead to a contest of imitating other's walks (especially the boss'). The performing participant chose this concept to be his favorite, because he expected to be amused by it at work. Five devices were about (2) '*enhancing inspiration and the feeling of superiority*', such as an "Info-Stethoscope", which allowed to listen into one's surroundings, or a concept named "The Third Ear", a device to identify animal sounds. There were two devices that were able to record, such as ongoing conversations. One participant, who characterized herself as a curious person, wanted to catch

and save interesting information with her device. Another person said that he would really enjoy recording, since he would love to share it. He wore a cochlear implant and wanted the device to be able to record exactly the way he perceives the world to share his way of hearing with his wife. He said it could be a little frightening to have the superior power to go back into the past by replaying recorded conversations and situations, but he would definitively enjoy doing so. Since he wanted to use his recording device as a device for sharing, it fits into the first main category '*enhancement of social interaction*' as well.

3.2.3 Methodological Findings: Agency of the PPP. The Prompts of Positive Possibilities (PPP) figured prominently in the enactments. For example, they influenced what kind of scenario a person thought of and this again often determined what kind of OP came into play. For example "Feeling independent from other people" made one participant (P9) think of herself being a pedestrian within road traffic. This in turn made herself grab an OP that could be worn hands-free. At the same time, the PPP were vague and could be interpreted in individual ways in relation to the specific everyday life of each participant. The given PPP changed, was adapted and further specified through the enactment. For example for P2 "being able to sense acoustic information with other modalities" was regarded to be an important issue at the workplace. When performing a work scenario the participant specified the PPP due to the enacted circumstances to "Being able to sense the identity of a person walking at one's back". Another participant (P6) was using the same PPP. But she wanted the rooms of her home to be interconnected with a smell-system. The same PPP became adapted to her specific lifeworld and was specified in yet another way. We ended up acting "Being able to smell the location of a speaker". Thus the PPP did not only spur activities, but was further evolved by the activities themselves.

3.2.4 Methodological Findings: Agency of the OPs. Although being completely technology-free, OPs became catalysts for imagining technology in action. They created and shaped a potential action space. Through their openness, their influence was diverse. For example, one participant (P10) aimed at "Understanding irony, emotional undertones and side notes". She wanted to be enriched by a device in a lecture situation. When she was introduced to the OPs, she spontaneously picked some kind of belt to become her "bossy-rope" (Figure 2). The OP inspired her to have a device that explicitly connects her to the lecturer. Every time, when the speaker faced away, she pulled the rope, so the speaker would turn to her again. Of course this idea is closely linked to the shape of the OP itself. The same participant thought of another device that allowed her to record conversations to replay them later. But this idea was rather inspired by the PPP. She wanted the device to be some kind of bracelet. So she picked an OP that resembled the bracelet-idea. Thus, sometimes (1) the probe stimulated the enactment and sometimes (2) the probe merely supported the enactment. During an enactment, the phases (1) and (2) often alternated, leading to series of metamorphosing devices. It was interesting to see where the action came from. Sometimes it was hard to tell whether participants used the probes or whether the probes used the participants.

Furthermore, the probe always impacted the imaginary setting of the enactment. For example, one participant used a probe that inspired her to something she called "Info-Stethoscope". With the help of the "Info-Stethoscope", she could 'listen-in' to every object to get additional information. She could, for example, listen to the ingredients of a meal in a restaurant. Reality and fiction melted. In her enactment, she ended up being a tourist in a botanic garden spying upon what was actually an indoor plant of the lab (Figure 3).

3.2.5 Methodological Findings: Agency of the Participant. Each participant with his or her individual lifeworld impacted the emerging future activities in a distinct way. Even when the same PPP combined with the same OP was used, we ended up with individual – and therefore strongly differing – meanings and materials.

Figure 2: A participant performing the "Bossy Rope".

Figure 3: Using the "Info-Stethoscope" in a 'botanic garden'.

Figure 4: Feeling safe with the "Data Protection Hood" and with the "Magic Magnifying Glass".

For example, when the PPP "Creating a shelter to feel safe in" and a string-shaped OP was used by P8 the activity of taking a walk while dragging a 50m long "Alarm-Leash" evolved. The leash would provide a signal when someone was approaching it. Taking the same PPP and the same OP another participant (P4) created the activity of a person scanning his implant with a "Magic Magnifying Glass" since he wanted to be sure his headache has nothing to do with the implant itself (Figure 4). When we involved another OP suddenly the first person (P8) imagined herself sleeping in her bedroom on a "Vibrating Mattress". The second person (P4) confronted with the same OP was however suddenly wearing a "Data Protection Hood" in his living room (Figure 4).

Further, the individual bodies of the participants played an important part in the enactments. There was not only free choice regarding the OP but also how to incorporate the probe with the body. Devices were closely connected to the body since they were supposed to enhance body functions. We co-designed predominantly wearables – most devices needed to be worn or carried around. Sometimes the probe almost became a part of the participant, while performing with it. Thus, the bodies were involved essentially, and they often determined the resulting device. For example, one participant (P8) first decided to wear a bracelet-alarm-system, but after performing with it, she decided that she would rather like to wear the device as a belt. When girding the belt she was suddenly imagining that it should warn her by inducing electric pricks. It was easy for her to imagine herself in a situation in which she would use a warning belt since she already acted with it. Performing ideas with one's own body made ideas tangible and let to further specification. For example, one participant (P2) came up with the idea of a telephone that would signal the emotional condition of the person at the other end of the line. When using this "All-Emotion-Telephone", he realized how important it is to allow for emotional ambiguity and to provide the opportunity to disable the device from time to time. We changed the imaginary functions of the device and this again impacted the enactment. The whole approach very much benefitted from thinking-through-making, -moving and -doing, as a form of Embodied Design [28,34,41].

3.2.6 Summary and Reflection. We prompted enactments of future activities involving divergent hearing through three 'components': (1) 'Prompts of Positive Possibilities' (PPP), suggesting different potential empirically-grounded positive meanings, (2) ambiguous 'Open Probes' (OP) in different shapes and (3) participants (P) with different bodies, hearing abilities and lifeworlds. We let them simultaneously and continuously create 'intra-action' in the sense of dynamic enactments to reify potential meaning and the potentially required technology. Everything evolved to be what it was because of the specific activity and vice versa (Figure 5). The whole process was like cooking without a recipe. The outcome was uncertain. The ingredients tasted different each time, depending on all other ingredients. In the words of Barad: there was no interaction between preexisting elements, but 'intra-action' where elements came into existence because of the action.

OPs apparently did not have much to do with conventional hearing aids or anything that could be considered to be 'normal'. After introducing the probes to the participants their reaction alternated between astonishment, amusement, surprise, or even confusion. This alienation opened space for thinking and doing in unconventional categories, yet through the PPPs the enactments remained tied to the concerns of the participants. The OPs did neither signify nor conceal 'non-normal' hearing. Instead of focusing participants on the insufficiency of their bodies or problematic situations in everyday life, our setup created openness for yet-to-be-imagined positive activities. In line with Barad's claims about 'intra-action', OPs and PPPs invited each other and the participants to respond. New positive activities shaped by meaning, material and person emerged (Figure 5).

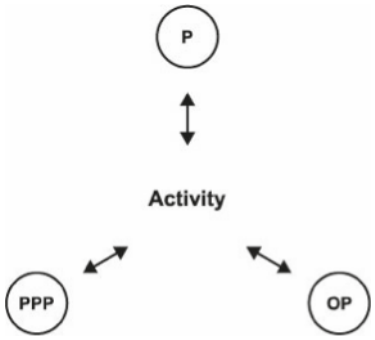

Figure 5: Participants (P), 'Open Probes' (OP) and 'Prompts of Positive Possibilities' (PPP) shaped by 'intra-action'.

The 'intra-active' dynamics included us as researchers. All 'components' were influenced by us in one way or another. The OPs were shaped by us in advance and the PPPs that resulted from step 1 were also framed by us. During the enactment, the participants were in continuous dialogue with the first author. We performed and discussed activities *with* them. Thus, while we believe our approach to be sufficiently open, we are well aware that it heavily depends on the researchers involved. To maintain a close connection to the concerns and lifeworld of real people, we based our PPPs on prior empirical findings. Moreover, we consciously designed the OPs to be worn close to the body, since our target technologies will be worn accordingly. However, this implies that future applications of the approach in other domains may not rely on our particular PPPs and OPs.

The suggested method aims at situatedness and the creation of concrete and very personal insights. Therefore, for instance, we consciously decided to create personalized PPPs. And in fact, for most of the participants it was much easier to get involved with their personal PPP than with the second random one, we provided them with. Through the enactments, we got a better understanding of what kind of enhancement a specific participant would appreciate and what he or she regards to be positive. Whether this specific enhancement is an idea valuable to others must remain open. With our study we do not make general claims about positive hearing for all people with divergent hearing. In this sense, our approach is idiosyncratic, anecdotal and primarily inspirational. Furthermore, we are aware that each of the 26 activities can set off a series of critical issues when transformed into more detailed designs, such as issues of data privacy, pressuring self-optimization or unequal power relationships. Thus, we consider our activities to be starting points for further critical reflection.

4 DISCUSSION

The impact of this study is twofold: First, developers of hearing aids may use our findings to extend and broaden their view on future hearing technologies. Second, the described co-design approach contributes to a possibility-driven design by adding a tool to design for positive activities.

4.1 An Alternative View on Hearing Devices

This study provides an alternative to the conventional way of dealing with divergent hearing. Instead of focusing on the problem of 'non-normal' hearing and aiming at restoring 'normality', we argue that more divergent ways of hearing (sensing) could be created – as long as they become meaningful to people through their positive impact on everyday life.

More specifically, the first step of this study revealed a number of already existing positive experiences with divergent hearing. For example, we found that for some people the visibility of hearing aids should not be 'designed away', but be utilized in a smart way. Innovative visible hearing aids could indicate the interest one has in others or signify the self-esteem of its user. Further, it is promising to investigate how a hearing aid could help busy people to experience quiet times in a recuperative way. Moreover, additional unconventional questions arose from our study, such as "How to design hearing aids that directly take the blame for a lack of content-related understanding?" or "Is it possible to create a hearing aid that supports mental focus and concentration even more?"

In the second step of our study, we went beyond existing positive experiences. In this process, 26 future positive activities and respective 'devices' emerged. Each device is a potential starting point for innovation. This is an unconventional strategy for the hearing aid industry. Typically, new aids result from technological advancements, i.e., innovation is technology-driven. In contrast, our approach supports innovation that takes everyday life and context into account. The 26 activities and according devices emerged through the 'intra-action' of positive meaning (PPP), ambiguous material (OP) and people. They are complex, personal, imagined entanglements, yet grounded in everyday life. Thus, each single activity contains valuable information about how hearing devices could support divergent hearing and how to introduce this meaningfully into the lifeworld of people. Importantly, most of our activities imply positive transformations even for people, who consider themselves to hear 'normally'. The change of perspective from problem-solving to possibility-creating is a chance for the hearing aid industry to consider hearing devices to do more than just repairing hearing loss.

4.2 Methodical Contribution to Possibility-Driven Design

Besides substantial findings concerning the future design of hearing technology, we provide a methodological contribution to the design for positive future activities. Approaches, such as Experience Design, Positive Design or Design for Wellbeing usually base their concepts on insights from positive activities people already experience. In the first step of this study, we have successfully drawn upon this approach. But by using already existing positive experiences for the design of new technology there is the risk of repetition or at least the risk of limiting oneself to given circumstances. Thus, in the second step, we went further and tested a more speculative approach. While it remains grounded in positive experiences, our approach puts a special focus on (the emergence of) positive activities that do not yet exist. Obviously, our 26 activities and devices did not originate in a vacuum. They remain bound to the everyday lives and imagination of the participants. However, by not limiting oneself to interviews, but using a

performative approach with ambiguous, open 'components' that are, in Barad's sense, able to respond, we discovered positive activities and potential devices not yet common to people. Thus, PPPs and OPs seem to be useful tools that could be further adapted to other positive design processes.

5 CONCLUSION

The present study focused on potential advantages of divergent hearing. For a problem-driven technology, such as hearing aids, this perspective is uncommon. We reframed 'non-normal hearing' as 'divergent hearing' to change its meaning from a disability to a possibility for enhancement and empowerment. One may argue that this is a rather cynical view, mainly sugarcoating the manifold problems arising from hearing loss. While we certainly neither want to trivialize problems nor argue against technological progress, we believe that a change of perspective is not only helpful, but also in the interest of people with divergent hearing. It broadens the view rather than limits it. In addition, participants neither found it inappropriate nor pejorative to talk about positive aspects of their divergent hearing. They enjoyed involving themselves in speculations about future activities and devices.

Besides the new perspective on 'non-normal' hearing and related technologies, the present study also provided an innovative methodological approach to explore potential positive activities and technologies involved. This approach neither started from a particular technology to speculate about emerging activities, nor from given activities to speculate about novel technologies. It simultaneously provided ambiguous meaning grounded in human experience and ambiguous material grounded in the human body. By instilling a performative dialogue among injected meaning, given material and the participant, possible activities emerged in which all elements mutually constituted themselves. On the one hand, each single of those entanglements is a useful anecdote by itself telling a situated story about a positive future activity, thereby serving as inspiration for design. On the other hand, it was possible to further group activities to provide an idea of the topics and technologies people with divergent hearing are interested in. In sum, we found fostering 'intra-active' dynamics through our particular method helpful and promising, both for exploring future activities in possibility-driven design and for changing the perspective on the predominantly problem-driven approach to hearing technology.

ACKNOWLEDGEMENTS

We thank our participants for their time and the Hörzentrum Oldenburg GmbH for supporting the recruiting. This work was supported by the German Federal Ministry of Education and Research (BMBF), project mEEGaHStim (Grant: 16SV7786).

REFERENCES

[1] Günther Anders. 2002. Die Antiquiertheit des Menschen II: Über die Zerstörung des Lebens im Zeitalter der dritten industriellen Revolution.C.H.Beck Verlag, München.

[2] Karen Barad. 2007. *Meeting the universe halfway*. Duke University Press, Durham, London.

[3] Ann Blandford, Dominic Furniss, and Stephann Makri. 2016. Qualitative HCI research: Going behind the scenes. *Synthesis Lectures on Human-Centered Informatics* 9, 1: 1–115.

[4] Eva Brandt and Camilla Grunnet. 2000. Evoking the future: Drama and props in user centered design. In *Proceedings of Participatory Design Conference PDC 2000*, 11–20. Retrieved from http://www.itu.dk/courses/I/F2004/PDC00-drama-endelig.pdf

[5] Citation Briggs, Pam Briggs, Mark Blythe, John Vines, Stephen Lindsay, Paul Dunphy, and James Nicholson. 2012. Invisible Design: Exploring Insights and Ideas through Ambiguous Film Scenarios.

[6] Marion Buchenau and Jane Fulton Suri. 2000. Experience prototyping. *Proceedings of the conference on Designing interactive systems processes, practices, methods, and techniques - DIS '00*: 424–433. https://doi.org/10.1145/347642.347802

[7] Pieter Desmet and Marc Hassenzahl. 2012. Towards Happiness: Possibility-Driven Design. In *Human-computer interaction: The agency perspective*, Marielba Zacarias and José Valente de Oliveira (eds.). Springer, Berlin, Heidelberg, 3–27. https://doi.org/10.1007/978-3-642-25691-2

[8] Pma Desmet and Ae Pohlmeyer. 2013. Positive design: An introduction to design for subjective well-being. *International Journal of Design* 7, 3: 5–19. https://doi.org/10.1108/10878571011029028

[9] Sarah Diefenbach and Marc Hassenzahl. 2017. *Psychologie in der nutzerzentrierten Produktgestaltung: Mensch-Technik-Interaktion-Erlebnis*. Springer, Berlin.

[10] Sarah Diefenbach, Marc Hassenzahl, Kai Eckoldt, Lena Hartung, Eva Lenz, and Matthias Laschke. 2016. Designing for well-being: A case study of keeping small secrets. *The Journal of Positive Psychology* 12, 2: 151–158. https://doi.org/10.1080/17439760.2016.1163405

[11] Fiona Dunne, Anthony; Raby. 2013. *Speculative Everything: Design, Fiction and Social Dreaming*. MIT Press.

[12] Maria Egbert and Arnulf Deppermann. 2011. Introduction. In Hearing Aids Communication: Integrating Social Interaction, Audiology and User Centered Design to Improve Communication with Hearing Loss and Hearing Technologies, Maria Egbert and Arnulf Deppermann (eds.). Verlag für Gesprächsforschung, Mannheim, 1–8. https://doi.org/10.1038/kisup.2012.51

[13] Maria Egbert and Arnulf Deppermann. 2011. Introduction to conversation analysis with examples from audiology. In *Hearing Aids Communication*, Maria Egbert and Arnulf Deppermann (eds.). Verlag für Gesprächsforschung, Mannheim, 40–47.

[14] Maria Egbert and Ben Matthews. 2011. User centered design: From understanding hearing loss and hearing aids towards understanding interaction. In *Hearing Aids Communication*, Maria Egbert and Arnulf Deppermann (eds.). Verlag für Gesprächsforschung, Mannheim, 48–55.

[15] Chris Elsden, David Chatting, Abigail C. Durrant, Andrew Garbett, Bettina Nissen, John Vines, and David S. Kirk. 2017. On Speculative Enactments. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17*: 5386–5399. https://doi.org/10.1145/3025453.3025503

[16] Sigmund Freud. *Civilization and its Discontents*. Penguin Books, London.

[17] Arnold Gehlen. 1988. *Man, his nature and place in the world*. Columbia University Press.

[18] Simone Groeber and Simona Pekarek Doehler. 2011. Hearing-impaired adolescents in a regular classroom: On the embodied accomplishment of participation and understanding. In *Hearing Aids Communication*, Maria Egbert and Arnulf Deppermann (eds.). Verlag für Gesprächsforschung, Mannheim, 76–89.

[19] Karin Harrasser. 2013. *Körper 2.0*. transcript, Bielefeld.

[20] Marc Hassenzahl, Kai Eckoldt, Sarah Diefenbach, Matthias Laschke, Eva Lenz, and Joonhwan Kim. 2013. Designing moments of meaning and pleasure. Experience design and happiness. *International Journal of Design* 7, 3: 21–31.

[21] Erich Hörl. 2010. Die künstliche Intelligenz des Sinns. Sinngeschichte und Technologie im Anschluss an Jean-Luc Nancy. *Zeitschrift für Medien- und Kulturforschung* 1, 2: 129–147.

[22] Hilary Hutchinson, et. al. 2003. Technology probes: inspiring design for and with families. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '03)*, 5: 17–24. https://doi.org/10.1145/642611.642616

[23] Giulio Iacucci and Kari Kuutti. 2002. Everyday life as a stage in creating and performing scenarios for wireless devices. *Personal and Ubiquitous Computing* 6, 4: 299–306. https://doi.org/10.1007/s007790200031

[24] Don Ihde. 1990. *Technology and the lifeworld: From garden to earth*. Indiana University Press, Indianapolis.

[25] Benjamin Johansen, Yannis Paul Raymond Flet-Berliac, Maciej Jan Korzepa, Per Sandholm, Niels Henrik Pontoppidan, Michael Kai Petersen, and Jakob Eg Larsen. 2017. Hearables in Hearing Care: Discovering Usage Patterns Through IoT Devices. In *Universal Access in Human–Computer Interaction. Human and Technological Environments*, 39–49.

[26] Benjamin Johansen, Michael Kai Petersen, Niels Henrik Pontoppidan, Per Sandholm, and Jakob Eg Larsen. 2017. Rethinking Hearing Aid Fitting by Learning From Behavioral Patterns. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA '17*: 1733–1739. https://doi.org/10.1145/3027063.3053156

[27] Elizabeth Keating and Pirkko Raudaskoski. 2011. Theoretical Framework: Communicative technology for augmented interaction within the field of Science, Technology and Society ("STS"). In *Hearing Aids Communication*, Maria Egbert and Arnulf Deppermann (eds.). Verlag für Gesprächsforschung, Mannheim, 35–39.

[28] David Kirsh. 2010. Thinking With the Body. 2864–2869. https://doi.org/10.4324/9780203450666_chapter_17

[29] Malene Patsche Kjeldsen and Ben Matthews. 2008. Talking about hearing: Designing from users' problematisations. In *Proceedings of the 5th Nordic conference on Human-computer interaction: building bridges.*, 531–534. https://doi.org/http://doi.acm.org/10.1145/1463160.1463237

[30] Holger Klapperich and Marc Hassenzahl. 2016. "Hotzenplotz" - Reconciling Automation with Experience. *Proceedings of the 9th Nordic Conference on Human-Computer Interaction*: 1–10. https://doi.org/10.1145/2971485.2971532

[31] Ray Kurzweil. 2006. *The Singularity Is Near: When Humans Transcend Biology*. Penguin Books, London.

[32] Joseph Lindley and Robert Potts. 2014. Anticipatory Ethnography: Design Fiction as an Input to Design Ethnography. 237–253.

[33] William Odom, John Zimmerman, Scott Davidoff, Jodi Forlizzi, Anind K. Dey, and Min Kyung Lee. 2012. A fieldwork of the future with user enactments. In *Proceedings of the Designing Interactive Systems Conference (DIS '12)*, 338–347. https://doi.org/10.1145/2317956.2318008

[34] Dennis Schleicher, Peter Jones, and Oksana Kachur. 2010. Bodystorming as embodied designing. *interactions* 17, 6: 47–51. https://doi.org/10.1145/1865245.1865256

[35] Martin E.P. Seligman, Tracy A. Steen, Nansook Park, and Christopher Peterson. 2005. Positive psychology progress: empirical validation of interventions. *The American psychologist* 60, 5: 410–421. https://doi.org/10.1037/0003-066X.60.5.410

[36] Louise Skelt. 2011. Dealing with misunderstandings: The sensitivity of repair in hearing-impaired conversation. In *Hearing Aids Communication*, Maria Egbert and Arnulf Deppermann (eds.). Verlag für Gesprächsforschung, Mannheim, 56–66.

[37] Bruce Sterling. 2005. Shaping Things (Mediaworks Pamphlets).

[38] Lucille Alice Suchman. 2007. *Human-machine reconfigurations*. Camebride University Press, Cambridge. Retrieved from http://scholar.google.com/scholar?q=related:sJbJxg4KmIUJ:scholar.google.com/&hl=en&num=20&as_sdt=0,5

[39] Danielle Wilde. 2015. Embodying Material Ideation. In *Participatory Innovation Conference 2015*, 386–393.

[40] Danielle Wilde and Jenny Underwood. 2017. Designing towards the Unknown: Engaging with Material and Aesthetic Uncertainty. *Informatics* 5, 1. https://doi.org/10.3390/informatics5010001

[41] Danielle Wilde and Anna Vallgårda. 2017. Embodied Design Ideation Methods: Analysing the Power of Estrangement. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 5158–5170.