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Experiencing the Future today: The Role of UX Demonstrators in Tactile Internet Innovation and its Impact on Technology Transfer

Lisa-Marie Lüneburg

With the introduction of the *Tactile Internet*, the vision of democratising the access to skills and expertise for everyone is closer to realisation than ever before. Enabling humans to interact with cooperative product-service systems through technologies such as wearables, exo-skeletons or other IoT devices inhibits a potential of disruptive innovations to significantly change our everyday lives. Therefore, in order to create out of this technological advantages meaningful applications for society in general a shift in academic research is required away from purely technology-oriented to socio-economic solutions (Mazzucato, 2018).

Acting like catalysts (Price, Wrigley, Matthews & Dreiling, 2014), human-centered design approaches facilitate the development of commercial applications in scientific research projects (Sainsbury, 2007). In addition, design-driven innovation processes add the human-centered perspective as a crucial factor for the success to innovative solutions: meaningfulness (Verganti, 2009). At present, tangible results of such scientific R&D processes are demonstrators that represent technological inventions without considering emotional needs of users respectively investors as well as the overall public value.
Based on theoretical approaches of user experience design and economics, this paper describes a project that aims to investigate measurable dimensions and design principles for these experience-centred demonstrators that support the transfer of scientific research into meaningful innovations.

Introduction

In the recent years, the large-scale adoption of 5G, the fifth generation of wireless communications technologies, evolved. Today, almost every telecommunication service provider in the developed world is upgrading its infrastructure to offer 5G data transmission. It is foreseeable that a comprehensive network will be available within the next decade.

Through 5G technology, new ways of communication arise. One of these paths leads to applications which enable near real-time feedback control in human-machine cooperation. Those applications enable humans to communicate with devices of their surroundings at tactile latencies, they are hence called *Tactile Internet.* The Tactile Internet is characterised by a data transmissions or more precisely a round-trip latency of 1 ms (Fettweis, 2014, p. 65). **Certainly, the innovation shift by the Tactile Internet is in progress and will dramatically reshape our society by touching nearly every segment of human life** like education, mobility and traffic, industry, health care, sports, entertainment, gaming, and the smart grid (Euripides, 2017).

Therefore, it is vital to ask in which way *Tactile Internet* technologies are beneficial to our society and individual well-being. This question marks the point of departure for our project called the *Tactile Internet with Human-in-the-Loop (TaHiL).* From a human-centred perspective, TaHiL conveys the Tactile Internet into valuable solutions by putting the human at the centre of all developments, with technology being an enabler for humans.

One of those identified opportunities is the *Internet of Skills:* TaHiL strives to democratise the access to skills and expertise promoting equity for everyone regardless of gender, origin, age or abilities. The use case Internet of Skills addresses novel ways of instruction and learning. Within TaHiL, soft exo-skeletons and wearables are developed, such as eGloves or eBodySuits that are controlled or pre-trained by an expert to help humans while learning to play an instrument, to perform sports, or to undergo rehabilitation.

This potential of disruptive innovations requires awareness of the consequences for individual human being and its development must be guided by obtaining the optimum in public value in general. Designers can be a crucial part in this process giving key impulses and direct research towards well-being and happiness in opposition to purely functional optimisation and financial growth (Desmet & Pohlmeyer, 2013).

Therefore, TaHiL applications need to be designed carefully considering how they can be applied in people's everyday life. In this sense, transferring a developed technology into markets is a key application issue for the *Internet of Skills.* In this process, science commercialisation represents a

key factor for economic growth (OECD, 2017) and acts as an important indicator for society and politics on the public value of a research project.
The next section discusses the challenges and knowledge gaps regarding design research-led innovations in order to develop meaningful TaHiL applications and their transfer into marketable innovations. Thereby, technology transfer includes creating patentable innovations that can be transferred to start-ups or existing companies. The term meaningfulness is applied in a sense of adding an emotional value to the user while interacting with an object. Furthermore, in the following *User Experience* (UX) is seen as an holistic design approach that puts the subjective perceptions, feelings and motivational aspects of human-machine interaction at the centre of the design process (Minge, Thüring & Wagner, 2016).
Lastly, a demonstrator is a prototype which enables the evaluation of the first concepts generated within the UX design process supporting the expansion of knowledge revealing potential limitations and opportunities by this embodiment or proof of the concept (BenMahmoud-Jouini & Midler, 2020, p. 66).

Research Gap

The technology transfer from universities to markets is continuingly relevant topic in research (Bozeman, Rimes & Youtie, 2015) and funding (Mazzucato, 2018). Especially technology-driven innovations must overcome various hurdles in technology transfer (Kim, Park, Sawng & Park, 2019). The most prominent among them is the *Valley of Death* (Wessner, 2005), which is also often referred to as the *Research-Market-Gap* (Mesa, Thong, Ranscombe & Kuys, 2019). In this phase, ventures often fail due to a lack of financial resources often caused by a technology-oriented rather than a market-oriented focus (Markman, Siegel & Wright, 2008).

A major reason for the gap is the high risk of incorrectly estimating the success of an innovation at an early stage of technology development and of wrongly predicting the market demand for the respective solution (Bozeman et al., 2015; Kim et al., 2019).

In fact, most technological innovations still fail because the added value of the emerging technology provided by the developed products fails to meet the needs and requirements of the market and users (Hoffmann, Lennerts, Schmitz, Stölzle & Uebernickel, 2016). Hoffmann et al. (2016) present the novelty and meaningfulness of innovations as the two central determinants that influence the perception of innovations by consumers.
This goes hand in hand with Verganti's (2009) approach of "meaningful innovation". Both Gardien und Gilsing (2013) as well as Petersen (2016) assume that meaningfulness will help innovations to have a significantly higher chance of success on the market. The question of which

processes and methods lead to meaningful innovations is a multi-layered issue where the aspects of the user experience are still open in the respective literature. User Experience Design (UX Design) allows for the development of successful digital products providing meaning and a positive experience. Accordingly, it holds enormous potential for the human-centered development of product-service systems (Marcus & Wang, 2019; Woelfel & Krzywinski, 2019). The positive experience of new technologies can reduce fear of use and increase the comfort of use as well as general usability (Desmet & Pohlmeyer, 2013).

The use of UX Design to create positive experiences when learning new skills with the help of cooperative product-service systems is still in its infancy and requires an expansion of the methodological horizon of UX Design.

User Experiences can be formed by positive emotions in various ways. Various dimensions of the pleasurable product experience are defined in the literature (Jordan, 2000; Norman, 2004; Desmet, 2012). Desmet (2012) assumes that positive emotions can be evoked by the object, the meaning of the object, the interaction with the object, the activity made possible by this interaction, ourselves and others involved in the interaction. The UX Design provides various methods in order to analyse, define and evolve a set of emotions. Prototyping is one important part of the UX Design process to work out these emotions and identify them together with the user creating a positive experience (Hartson & Pyla, 2012).
In both research and innovation processes, demonstrators are the means to test, communicate and advance ideas in iterative development steps (Diefenbach, Christoforakos, Maisch & Kohler, 2019). In addition, they offer the potential to evaluate innovative solutions with regard to their transfer potential and to identify whether and how the developed application generates a significant added value for users. In the area of the TaHil research project, physically tangible demonstrators are created, which currently have different functions:

- Further development and verification of research hypotheses, conducting experiments and trail studies
- Communication of research results internally (boundary object)
- External communication of research results (transfer object)

The opportunity to use demonstrators and UX design methods to evaluate the progress of an innovation or transfer process with end users and other stakeholders, and thus to assess the chances of success of a technology application in the market more reliably, is given little consideration in the literature. Besides, there are no means available to feed the evaluation outcome as design-specific parameters back into the development process. **The role of experience-centred**

demonstrators in systematically transforming research results into meaningful innovations is largely not well understood yet.
The following identified transfer functions of demonstrator as "translator objects" (Moultrie, J., 2015) therefore need to be investigated further:

- Persuasion of stakeholders to further development and market introduction through positive perception of innovation (persuasion function)
- Validation of the success prospects of the meaningful innovations (forecast function)

Based on this gap in research, the central research question of this project arises:

- How does a positive demonstrator experience affect the transfer of TaHiL technology into meaningful innovations?

In view of this question several sub-questions follow up:

1. What dimensions of demonstrators evoke positive emotions?
2. In which way can positive demonstrator experiences result in positive innovation perception?
3. How does an experience-centred demonstrator facilitate forecasting the probable success of an innovation?

Overall this study hopes to gain more insight in how user experience design promotes the development of meaningful innovations.
In order to answer these questions, the next sections discuss existing design-led approaches heading towards meaningful innovations. The main focus lies on demonstrators with their multiple functions within research and development processes.

Research Objective

This paper presents a research proposal with the aim to understand the impact of experience-centred demonstrators on technology transfer. More precisely based on theories at the intersections of the respective disciplines of Design, Economics and Psychology, it investigates the possible impact of experience-centred demonstrators on the chances of success of a technology transfer from the TaHil research project into marketable innovations.
First, the functions of demonstrators in research and innovation processes are compared and categorized. On this basis, models and theories outlining meaningfulness as a factor of success in innovation are presented. The synthesis of this results from the integration of user experience approach in the initial phase of innovation processes with the help of demonstrators.

Literature Overview

The literature review has been conducted in two stages. Through an initial search the intention was to identify and specify the research gap along the question "What are the barriers to the transfer of academic research to the real world and how can design facilitate this transfer?".

In a second step, the literature review has been focused on previously defined relevant disciplines and keywords. The returned sources have been analysed based on their abstract. The findings have been categorised according to the scientific outcome. The review strategy is visualised in Figure 1.

The Role of Demonstrators in Science, Innovation and Design

As a first step, it is important to define and characterise the role of demonstrators in science, innovation and design. Common to all relevant literature is that they describing prototypes as indispensable artefacts for creating innovations (Brown & Kātz, 2009; Diefenbach et al., 2019; Exner, Lindow, Buchholz & Stark, 2014; Fiorineschi & Rotini, 2019; Gardien, Deckers & Christiaansen, 2014). With this purpose, they fulfil a variety of functions (BenMahmoud-Jouini & Midler, 2020; Bogers & Horst, 2014; Graham, Greenhill & Callaghan, 2014). Hereinafter the focus lies on current key publications regarding prototypes and demonstrators, their position and use in the innovation processes as well as how they create meaning through user experience design.

Accordingly, prototypes are defined in this work as artefacts that represent "a physical and/or digital embodiment of critical elements of the intended design, and an iterative tool to enhance communication, enable learning, and inform decision-making at any point in the design process" (Lauff, Kotys-Schwartz & Rentschler, 2018). As such they are "purposefully formed manifestations of design ideas" (Lim, Stolterman & Tenenberg, 2008).

BenMahmoud-Jouini and Midler (2020) characterise three different archetypes of prototypes in new product development:

(1) *the stimulator* which triggers interactions, for example, feedback from users, and acts as translator between developers as well as external stakeholders;

(2) *the demonstrator* which generates ideas and identifies new opportunities; and

(3) *the validator* for verifying hypotheses.

Demonstrators enable evaluation of the first concepts and support knowledge acquisition which often lead to further concepts. They reveal the potential limitations and opportunities by the embodiment of an innovative idea or proof of concept. (BenMahmoud-Jouini & Midler, 2020, p. 66)

Lyly-Yrjänäinen, Aarikka-Stenroos und Laine (2019) similarly use the term "mock-up" to describe an artefact which enables the preliminary measurement of cost and value implications

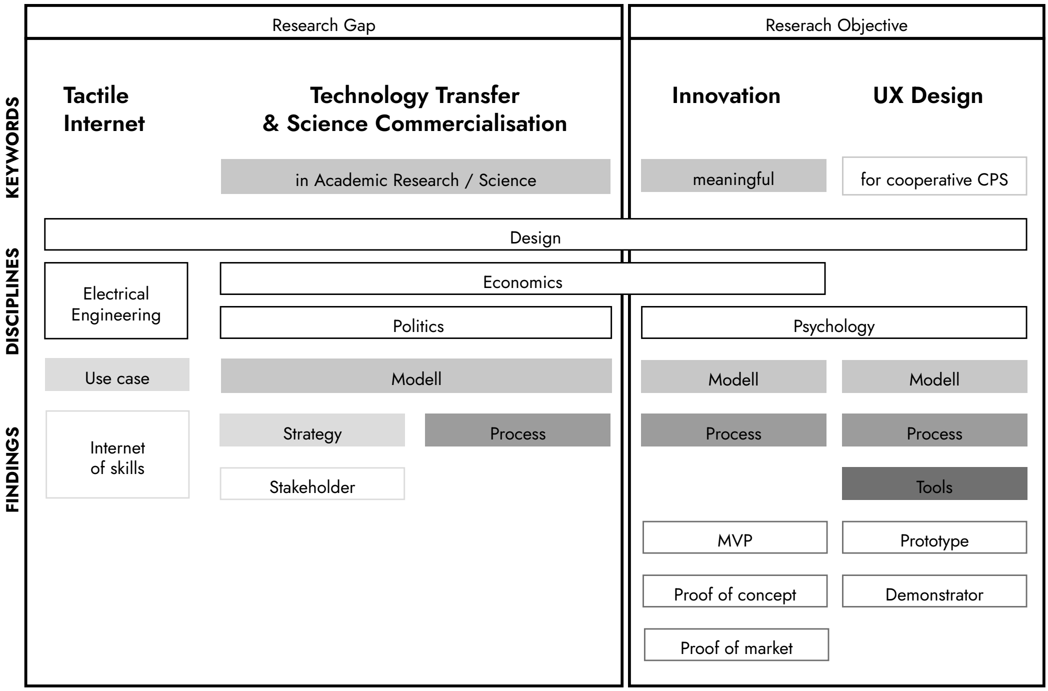

Fig. 1: Literature Overview

of a new product at the early stages of the development process. Thus, the demonstrator is used to validate a business case with "user-experienced" cost information and, therefore, also "perceived" customer value (Lyly-Yrjänäinen et al., 2019, p. 15).
In science, designers can act as research catalysts by supporting scientists in demonstrating, communicating and exploring potential future applications by creating demonstrators (Driver, Peralta & Moultrie, 2011). Moultrie (2015) defines them as technological prototypes which are close to market. In this capacity, demonstrators enable scientists to connect the public and academia to better communicate the potential purposes of academic research. Furthermore, Moultrie recognizes that demonstrators facilitate the communication to potential investors (2015).
In conclusion, it is to say that demonstrators are artefacts which are created in an early stage of development processes. Their main objective is to communicate innovative concepts to external stakeholders such as end-users, investors or other developers e. g. scientists. By validating the potential of a possible technology adaption, demonstrators could support scientist leading their research towards the socio-economic needs of current and future societies. In the following, factors of an economic perspective are presented regarding the transfer of technologies as successful innovations into the market.

Meaningfulness as a Factor of Success in Innovation
According to recent research, technological and functional advantages over existing products are not a guarantee for success in innovation (Chiesa and Frattini, 2011). Hence, over a third of all new products are not accepted by consumers (Feiereisen et al., 2008). The success of an innovation depends largely on how it is perceived and assessed by the user (Henard and Szymanski 2001).

Dimensions of Innovation Perception
Meaningful innovations are perceived as desirable, useful and convenient (Arts et al. 2011). Consumers balance between perceived profits and losses that result from the integration of an innovation into their daily routine to what extent they are adapted in (Tomczak et al. 2016). The perception of meaningfulness is dependent on the functionality and usability of an innovation as well as emotional and psychological considerations (Gourville 2006). This can be exemplified by the reaction of the social environment regarding the usage of an innovation or the level of joy associated with it (Tomczak et al. 2016). The Unified Theory of Acceptance and Use of Technology (UTAUT) provides seven factors that decisively influence the perceived meaningfulness of an innovation (Venkatesh et al. 2012):

- Performance
- Estimated effort
- Social influence

- Facilitations
- Hedonic motivation
- Value for money
- Habit

Within the context of the St. Gallen Business Innovation Model, the meaningfulness of an innovation is rated as the main criteria for the customer's purchase decision which is a multi-layered and complex process to assess (Tomczak et al. 2016). This is especially the case in the transfer of academic outcomes into the market. Concerning this issue, Bozeman et al. (2015) define a well-established and widely discussed model, which proposes six plus one dimension of technology transfer as shown in Figure 2.

Technology Transfer Dimensions
The Contingent Effectiveness Model characterises impacts of technology transfer in terms of who is doing the transfer, in which way and what is transferred to whom. The effectiveness of a transfer process can be assessed according to Bozeman et al. (2015) by seven criteria including (1) out-the-door (has anything been transferred?), (2) market impact, (3) economic development, (4) political advantage, (5) development of scientific and technical human capital, (6) opportunity cost consideration an and (7) a new additional effectiveness criterion: public value. The criterion Public value was added to his model after revising technology transfer literature: "A society's "public values" are those providing normative consensus about (1) the rights, benefits, and prerogatives to which citizens should (and should not) be entitled; (2) the obligations of citizens to society, the state and one another; (3) and the principles on which governments and policies should be based." (Bozeman et al., 2015, p. 41)

The model provides criteria for the assessment of technology transfer. It has to be proven on which of these criteria demonstrators can have a positive impact in communicating as well as generating an increase of its position. However, the wide range of factors determining if and when a particular R&D project will result in commercial or other benefits and the often long duration for a research project to achieve results, makes measuring the performance of science-related projects difficult (Bozeman et al., 2015).
Regarding meaningfulness, the identified seventh dimension of Bozeman "Public value" underlines the importance for innovations to address the different stakeholder's socio-economic needs in order to create a symbolic and emotional valuable product. Formerly framed by Verganti (2009) and Utterback, design-inspired or design-driven innovation has the potential for including those needs in the development process, for creating meaningful applications and as a consequence for achieving a higher success on the market. According to Utterback and colleagues (2006), successful innovation can be defined as the right balance between technology, market and significance.

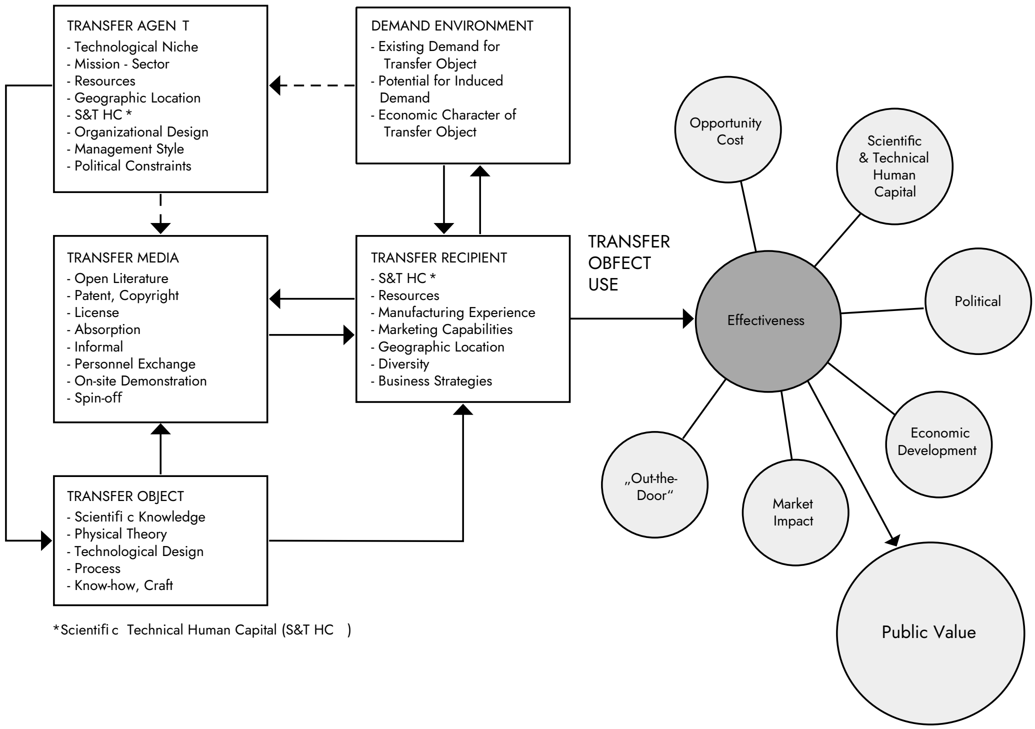

Fig. 2: Contingent Effectiveness Model of Technology Transfer after Bozeman et al. (2015)

As a conclusion one can say that the current literature on innovation research as well as technology transfer shows that emotional and social needs have a significant impact on the success of the introduction of a technology into the market. Verganti (2006) gives an impulse on how design could contribute in creating meaning. However, the question in which way design methods enhance the meaningfulness and thus the innovative potential of a technology remains still open.

Creating Meaning through User Experience Design

User experience (UX) is a holistic design approach that emphasizes on subjective perceptions, feelings and motivational aspects interacting with a product (Minge et al., 2016). It divides several facets of product perception such as usability, aesthetics, social communication of personal values, emotional stimulation and motivational support. The CUE model clusters those in instrumental and non-instrumental qualities (see Figure 4). Emotions that may occur through a product usage mediate between both qualities of perception (e. g. overall judgment, acceptance and intention to use) (Minge et al., 2016). In order to understand what drives a positive user experience, emotions evoked by the product as such, as well as by the activity of using the product, or by people who are involved in the interaction need to be considered (Desmet, 2012). Desmet (2012) introduces a set of emotions that represents the general repertoire of positive human emotions and how these emotions can be experienced in human-product interactions. Emotions are experienced in response to their context such as other objects, persons, or events that are associated with or symbolized by a product. Furthermore, the awareness and the sensitive choice of emotions to be evoked is crucial for designed objects as they often transport intangible values or beliefs (Desmet, 2012). When using complex technology, positive emotions decrease usage anxiety and constitute the basis of a satisfying user experience which is the key to success for any technical device (Desmet, 2012; Minge et al., 2016). Prototyping is an important part of the user experience design process to identify these emotions and elaborate them together with the user creating a positive experience (Hartson & Pyla, 2012). In terms of developing business impact one should be aware of the benefits of the various prototypes. Diefenbach (2019) outlines the power of UX prototyping for decision makers which often require proof points. Therefore, different forms of prototypes have to be validated as well as the solution space which is needed to bridge awareness to interest, desire and, finally, real action (Diefenbach et al., 2019). Thereupon she establishes a stakeholder-based perspective. To define and determine the target group has been repeatedly identified as a central aspect for the choice of appropriate prototyping methods (Diefenbach et al., 2019). Furthermore, experience prototyping enables to demonstrate

context and to identify issues and design opportunities. The prototyping goal is to provide a high fidelity simulation of an existing experience which is difficult to experience in real environment (Buchenau & Fulton Suri).
In this section the role of demonstrators, which form a special group of prototypes, is presented with focus on their potential in innovation processes. Well-established theories and models of the respective disciplines are linked with each other. They will serve as basis for the following research in identifying relevant properties and dimension of User Experience demonstrators impacting technology transfer. In order to assess the influence of a positive demonstrator experience on innovation perception a potential research design is proposed in the next section.

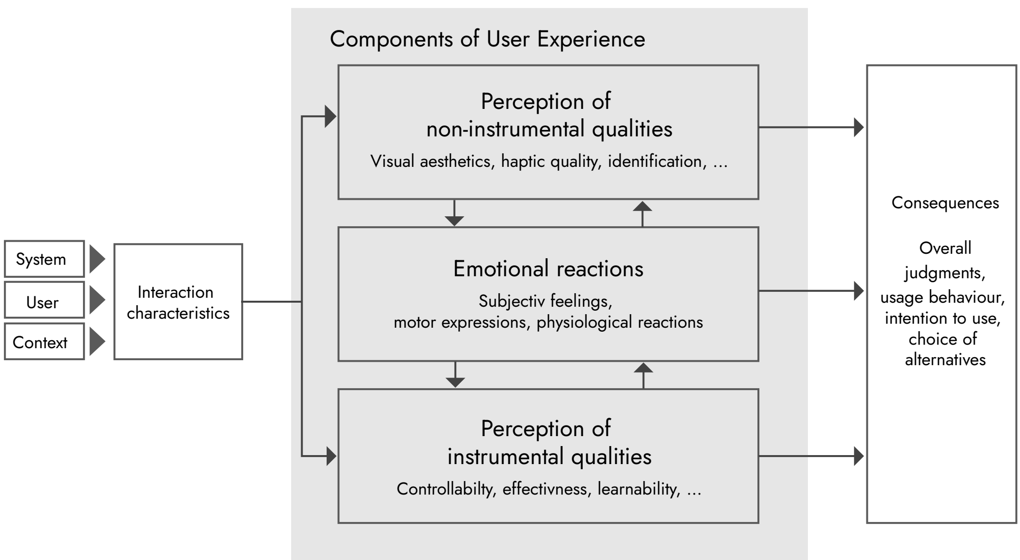

Fig. 3: CUE model (Thüring & Mahlke 2007)

Research Methodology

The methodological approach of this research proposal is comprised of various qualitative and explorative studies in order to tackle the question of how user experience demonstrators can facilitate the technology transfer of TaHiL applications.

To investigate the research questions above, a mixed-methods approach is chosen. The methodology of qualitative research is well-suited as the field of assessing the user experience of product-service systems is in its beginning of exploration. Through the use of naturalistic methods such as participant observation and open interviews, as initial information on the formulation of hypotheses can be obtained for subsequent, standardised and representative surveys (Flick, Kardorff & Steinke, 2017). Based on the principle of comprehension it provides insights of complex relationships in human interaction. Furthermore, investigation tools which allow to reveal implicit everyday life knowledge will be important in order to measure the meaningfulness of an innovation.

As a starting point, use cases could serve in the first phase of the study to survey relevant dimensions of demonstrators and their perception through the exploration and analysis of their subjective meaning and its influential factors.
In a second phase, a study which initially tests research methods in order to assess the innovation perception through a demonstrator will be conducted. Due to the embedded intelligence in TaHiL demonstrators quantitative data while interacting with the demonstartor can be recoreded and linked with qualitative findings (van Gent et al., 2011).
In a third phase, findings of the two previous studies will be operationalised followed by an evaluation of their ability to support designers in research projects creating and evaluating meaningful innovation demonstrators.
This preliminary research design serves as framework for exploring user experience demonstrators. In this process findings may occur which suggest changes of research instruments and methods. In the final section the contributions of this research will be presented.

Outlook

This paper presents a study with the aim to explore how experience-designed demonstrators create meaning. Within this scope the presented theories and models from the disciplines of design, economics and psychology can help to identify dimensions for demonstrators embodying cutting-edge innovations.
The possibilities of these demonstrator dimensions range from providing practical support for a systematic design of demonstrators and prototypes in general (e.g. positioning in the innovation process, choosing the right method for particular stakeholders), extending collaborations through prototyping in academic projects to not

only providing support on how to get a pleasant aesthetics (e.g. styling) but also on which meaning and purpose should be relevant for the targeted audience.

Regarding TaHiL, the question arises to what extent one can accept or be enthusiastic about something if its application is still in the distant future. For assessing user interactions with new technologies or design prototypes they need to be experienced in "real life" (van Gent et al.). Therefore a space is needed which enables to observe and record interactions using embedded electronics that are unobtrusively built into the surrounding environment. These environments are called experimental design landscapes (van Gent et al.) or in a long-term installation Experience Lab which is a room where demonstrators can be rapidly build up and tested with stakeholders in an natural context (Gardien et al., 2014).

Altogether, this study wants to develop a framework which systematically guides the design and evaluation of future technology applications as Tactile Internet with Human-in-the-Loop devices towards meaningful innovations improving everyone's everyday life. Enabling an authentic forecast of the intended adaption of this technologies by future users, demonstrators designed and evaluated by this framework could serve as important indicators in decision processes or gaining point of proof in the technology transfer process.

Acknowledgment
Funded by the German Research Foundation (DFG, Deutsche Forschungsgemeinschaft) as part of Germany's Excellence Strategy – EXC 2050/1 – Project ID 390696704 – Cluster of Excellence "Centre for Tactile Internet with Human-in-the-Loop" (CeTI) of Technische Universität Dresden.

Contact

Dipl.-Ing. Lisa-Marie Lüneburg
Königsbrücker Str. 58
01099 Dresden
lisa-marie.lueneburg@tu-dresden.de

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