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Eliciting Potential for Positive UX Using Psychological Needs: Towards a User-Centered Method to Identify Technologies for UX in the Car Interior

Valeria Bopp-Bertenbreiter[1], Stefan Klein[2], Doreen Engelhardt[2], Lena Rittger[2], Frederik Diederichs[3], Harald Widlroither[4], and Matthias Peissner[4]

[1]Institute of Human Factors and Technology Management University of Stuttgart, BW 70569, Germany
[2]Audi AG Ingolstadt, BY 85057, Germany
[3]Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB Karlsruhe, BW 76131, Germany
[4]Fraunhofer Institute for Industrial Engineering IAO Stuttgart, BW 70569, Germany

ABSTRACT

Positive user experiences (PUX) in the vehicle interior will be enabled by choosing the technologies with the potential to provide such experiences. Design for PUX in general exists, but methods to assess and compare technologies regarding their PUX potential are missing. Building on the insight that fulfillment of basic psychological needs may lead to PUX (Hassenzahl et al., 2010), this paper presents the first iteration of the user-centered method Tec4UXNeeds. Tec4UXNeeds combines VR representations of technologies and half-structured interviews to identify PUX potential of technologies: which basic psychological needs a technology may fulfill and in which use cases the technology could be used to enable need fulfillment. The method is applied for two display technologies in a standardized within-subjects study ($n = 27$). The study investigates whether the method Tech4UX enables participants to describe whether a technology has a potential to fulfill psychological needs for them and whether the method is specific enough to find differences in need fulfillment potential between technologies described by participants. Preliminary results identified distinct levels of need fulfillment for the first and second display technology (Display on Demand & Holography). Data will be analyzed further using qualitative content analysis. The method will be optimized iteratively in the future.

Keywords: UX potential, Need fulfillment, Methods, Positive user experiences, User-centered development, Technology assessment, Tec4UXNeeds

INTRODUCTION

Future positive user experience (PUX) of automotive brands will depend on implementing innovative technologies into the interior of the future and applying them in a suitable context for PUX. User experience is defined as "user's perceptions and responses that result from the use and/or anticipated use of

a system, product or service […] [including] […]the users' emotions, beliefs, preferences, perceptions[…]." (ISO International Organization for Standardization, p. 4) Technologies are defined as the know-how to solve a technical problem, which, once applied, results in technical solutions (Bullinger 1994). Understanding the PUX potential of technologies early on in the product development of a vehicle will be a key factor to satisfy customer needs in the appropriate use cases for future vehicles (Rittger & Schrader, 2021).

Assessing Technology Potential Regarding User Experience

Methods from technology management are used to assess emerging technologies: The technology potential analysis identifies relevant applications, technological and economic potential of a technology (Ardilio, 2013). Bauer et al. (2019) combine methods of traditional technology management with a user-centered approach. They identify a technology's relevant application scenarios by combining the Delphi method (Niederberger & Renn, 2019), literature reviews, impact analysis, and expert discussion. These scenarios are transferred into Virtual Reality (VR) to assess user acceptance. While these methods are valid for traditional technology assessment, their focus lies on technology potential for technological and economic development, not PUX. Like Bauer et al. (2019), this work uses VR to make technologies experienceable.

User Experience as a discipline provides several approaches to develop towards PUX: Positive design aims to develop for a range of positive emotions (Desmet, 2012), while the Experience Categories approach seeks to enable activities experienced as positive (Haspel et al., 2020; Laib et al., 2017). The need-based approach develops for PUX through the fulfillment of basic psychological needs (Pollmann et al., 2018), as need fulfillment during human-machine interaction may lead to PUX (Fronemann & Peissner, 2014; Hassenzahl et al., 2010). Furthermore, human development and well-being depend on the fulfillment of needs (Deci & Ryan, 2000). Therefore, the needs-based approach is used as foundation of this work. Need-based methods include replicating PUX patterns for fulfillment of specific needs (Knobel et al., 2012), building PUX from scratch based on the needs (Eckoldt et al., 2013), eliciting user improvements for product concepts with the needs serving as a basis for ideation (Fronemann & Peissner, 2014) or using needs profiles to create empathy in the developers for the users' perspective (Krüger et al., 2017). However, methods to explicitly elicit and compare technologies' potential for PUX and to identify suitable use cases early on in product development are currently missing. This paper contributes to the state of the art by introducing a method to assess which needs a technology may fulfill once it is implemented in the vehicle.

TOWARDS A METHOD TO IDENTIFY NEED FULFILLMENT POTENTIAL OF TECHNOLOGIES IN THE CAR: TEC4UXNEEDS

Fulfilling basic psychological needs seen as particularly relevant in human-machine interaction (Fronemann & Peissner, 2014; Hassenzahl et al., 2010) a promising approach to enable PUX. Therefore, it is crucial to identify the

need-fulfillment potential of technologies to choose the best technology for desired PUX (Bopp-Bertenbreiter et al., 2021). Consequently, in this work a technology's potential for PUX is defined as *assessment of which basic psychological needs a technology may fulfill and in which use cases the technology could be used to enable need fulfillment.*

As UX is a subjective impression of individuals (ISO International Organization for Standardization), we propose user-based approach for the Tech4UXNeeds method. This enables us to investigate whether a technology has certain "basic need-fulfillment impacts" on users, which are shared throughout the user base or whether user experiences of technologies differ immensely.

Phase 1: Gather Data & Make the Technology Experienceable

To assess a technology's need fulfillment potential with users, Tec4UXNeeds applies an approach similar to Bauer et al. (2019) to make the technologies experienceable: Expert knowledge of the technologies (basic functions, limitations, and maturity level) is turned into VR representations. The advantage of VR is to let users experience emerging technologies not yet applicable in real world to enable assessment, following the information acceleration approach (Urban et al., 1996). Utilizing VR to let users experience technologies furthermore enables comparison of technologies in the same environment, with the same content design, regardless of the influence the quality of real-world prototypes might have.

Phase 2: Elicit Need-Fulfillment Potential of Technologies in a Standardized User Study

After participants of the user study experience a technology in VR, Tech4UXNeeds explores the *PUX potential through need fulfillment* for the technology using a mixed-methods approach: need fulfillment is measured quantitatively through the needs questionnaire (Sheldon et al., 2001) in the version translated by Diefenbach and Hassenzahl (2017). Qualitative data is utilized to assess need fulfillment in participants' own words and to gain a deeper understanding on reasons for need satisfaction or frustration through experiencing the technology.

In a half-structured interview, adapted need cards (Siegen University) introduce 8 basic psychological needs to the participants through definitions, associated words, quotes and figures. For each need, participants are asked to answer the questions stated below (using the need "Autonomy" as an example). Laddering (Reynolds & Gutman, 1988) is applied to investigate reasons for need fulfillment:

1. *What did you experience? Did you feel autonomous/ self-reliant/self-determined when experiencing the technology?*
2. *How can this technology enhance the autonomy experience? How would the experienced technology need to be optimized so that you would feel more autonomous when experiencing the technology? Give examples.*
3. *In what situations can this technology enhance the autonomy experience? In what situation/use cases should the experienced technology be used*

to make you feel as autonomous as possible? Please describe concrete situations.

A scale from *0 – "No potential: I don't feel autonomous at all with this technology."* to *100 – "Very high potential: I feel extremely autonomous with this technology."* then asks participants to assess the technology's potential to fulfill the need, given optimization and suitable situation. An "Assessment not possible" option is given.

Research Questions for First Application of the Tec4UXNeeds Method

For the first application of the method, the following research are investigated:

- Research Question 1: *Does the method Tech4UXNeeds enable participants to describe whether a technology has a potential to fulfill psychological needs for them, i.e., to assess a technology's potential for PUX?*
- Research Question 2: *Is the method Tech4UXNeeds specific enough to find differences in need fulfillment potential between technologies described by participants, i.e., to differentiate between their PUX potential?*

FIRST ITERATION OF THE TEC4UXNEEDS METHOD

A first application of the Tech4UX method was conducted to validate and iteratively optimize the method. The method was applied for two technologies to investigate RQ 1 & 2.

For phase 1 of the Tech4UXNeeds method, company-internal experts for the respective technologies were asked to provide information and available materials to realistically represent the technologies' basic functions and limitations in VR. VR representations were implemented using the game engine Unreal Engine © and the Head-Mounted Display HTC Vive Pro ©. The VR representations were then shown to the experts for the respective technology to ensure realistic representation.

In phase 2, a within-subjects design was used for two technologies which basic function it is to visually communicate information: "Display on Demand" and "Holography". The VR representations of the technologies were experienced in a VR state-of-the-art vehicle interior (see fig. 1) in randomized order. To allow for cost-efficient technology assessment and to reduce possible influence of content on need fulfillment, the VR representations of the technologies were implemented to show only the basic functions of the technologies: For each technology, the same globe was implemented as exemplary content.

Sample. 27 participants (33% female, 67% male) took part in the study. The mean age was 35.33 years ($SD = 10.38$, $Min = 20$, $Max = 60$). Each session lasted 100 to 130 minutes. Participants were company-internal due to confidentiality of the technologies and received no financial compensation.

Figure 1: Vehicle interior as represented to the participants in VR.

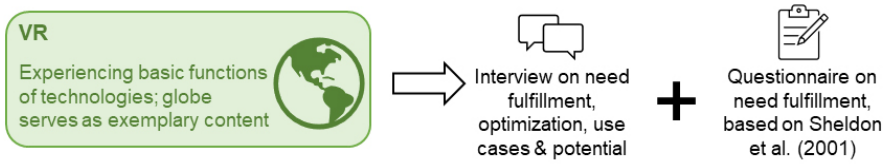

Figure 2: Procedure carried out for each technology in the user study.

Procedure. After informed consent, demographic data and previous knowledge of the respective technology was obtained. Participants then familiarized themselves the VR environment using the interior of a series vehicle (see fig. 1). Participants experienced the procedure shown in fig. 2 for both technologies. Verbal statements of participants were noted down by a minute-taker, as audio recording was forbidden by company regulations.

Coding the data. The first verbal question on need fulfillment potential *("What did you experience? Did you feel autonomous/ self-reliant/self-determined when experiencing the technology?")* was prepared as a yes/no-alternative, but participants often answered gradually. Therefore, participants' responses were categorized into a scheme by two independent raters for further analysis: "Yes" (experiencing the technology leads to need satisfaction), "No" (experiencing the technology does not lead to need satisfaction), and "Unable to assess" (could not assess need satisfaction in this form of experiencing the technology).

PRELIMINARY RESULTS

This paper presents preliminary results of the first iteration of the Tech4UXNeeds method, especially regarding the first verbal question. A deeper analysis of the data by qualitative content analysis is in preparation. 3 of the 30 participants overall had to be excluded due to missing data, resulting in 27 valid participants. Figure 3 shows descriptive results of the needs questionnaire (Sheldon et al., 2001) in the version translated by Diefenbach and Hassenzahl (2017).

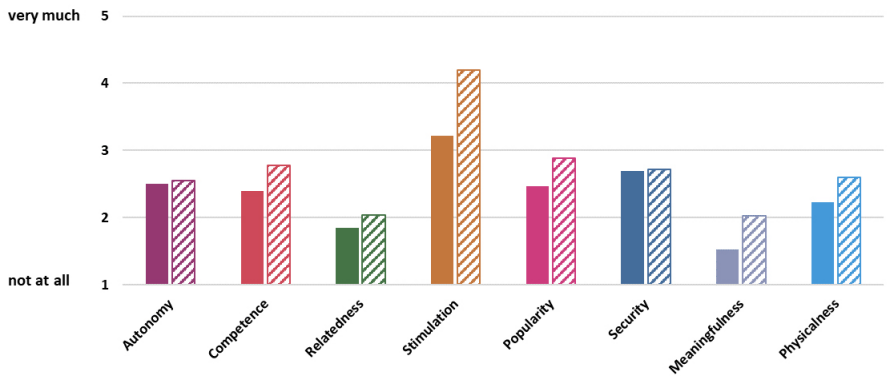

Figure 3: Need fulfillment while experiencing the technology, assessed using an adapted version of the translation by Diefenbach and Hassenzahl (2017), based on Sheldon et al. (2001).

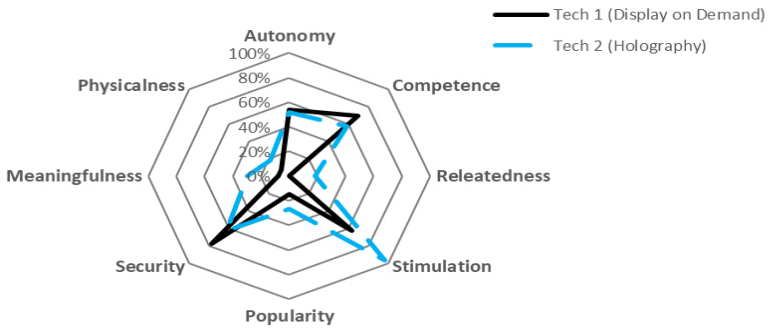

Figure 4: Satisfaction of respective need through experiencing the technology. Shown as percentage of "yes" responses to first verbal question. 100% = number of subjects able to assess experience.

Table 1. Interrater reliability – Cohen's Kappa κ with 95% confidence intervals (CI).

Need	Tech 1: Display on Demand	Tech 2: Holography
Autonomy	0.86; 95%CI [0.69, 1]	0.93; 95%CI [0.78, 1]
Competence	0.87; 95%CI [0.70, 1]	0.86; 95%CI [0.67, 1]
Relatedness	1.00; 95% [1, 1]	0.87; 95% [0.61, 1]
Stimulation	1.00; 95% [1, 1]	1.00; 95% [1, 1]
Popularity	1.00; 95% [1, 1]	0.75; 95% [0.5, 1]
Safety	0.89; 95% [0.67, 1]	0.92; 95% [0.76, 1]
Meaningfulness	0.65; 95% [0.02, 1]	0.91; 95% [0.73, 1]
Physicalness	0.45; 95% [0.04, 0.87]	0.89; 95% [0.67, 1]

For verbal question 1 (see fig. 4; need fulfillment while experiencing technology), interrater reliability was assessed using Cohen's Kappa κ

(see Table 1). Values above 0.6 indicate substantial agreement (Landis & Koch, 1977).

Reasons for need satisfaction or frustration while experiencing the technologies (verbal question 1) will be further analyzed. Answers to verbal questions 2, 3 and 4 seem to differ distinctly between technologies and will be further investigated by means of a qualitative content analysis.

CONCLUSION & OUTLOOK

Data reviewed so far indicates that the method Tech4UXNeeds provides a promising approach to assess PUX potential of technologies. Regarding RQ1, the method Tech4UXNeeds enables participants to describe whether experiencing a certain technology has a potential to fulfill psychological needs for them: For all needs, at least 85% of participants were able to express their need fulfillment verbally. Four participants, however, mentioned that they would need to interact with the technologies to assess their degree of need fulfillment for competence for Tech1: Display on Demand. As response patterns differ between technologies and needs, RQ 2 (*Is the method Tech4UXNeeds specific enough to find differences in need fulfillment potential between technologies described by participants, i.e., to differentiate between their PUX potential?)* may be answered positively.

Next steps will include a qualitative content analysis of reasons for satisfaction or frustration of different needs per technology to better understand under which conditions a technology may fulfill a respective need. Participant's suggestions for technology optimization to better fulfill a need will be clustered to identify whether patterns emerge. Participants stated use cases in which the technology should be used to fulfill a particular need as well as possible. These will be analyzed to learn whether there are use cases in which a technology can fulfill a need particularly well for many users. Such technology-use case combinations would be promising for follow-up studies and for optimizing implementation and operation of technologies to enable fulfillment of a specific need. To optimize the Tech4UXNeeds method, reasons for "inability to assess degree of need fulfilment" will be examined, e.g., how a technology must be experienced to enable such estimation. Optimization ideas include basic interaction for standard use cases or using a VR interior of a fully automated vehicle. Further studies will include a set of questions to assess conditions that further facilitate evaluation of need fulfillment potential. Results are going to be discussed regarding applicability in development towards PUX with experts from industry and science to further streamline the Tec4UXNeeds method.

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