UNeedS: Development of Scales to Measure the Satisfaction and Frustration of 13 Fundamental Needs

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ABSTRACT

Good user experience can be described as the result of satisfying fundamental human needs through interaction with technology. Therefore, HCI researchers and practitioners strive to promote need satisfaction and avoid need frustration through their technology and interaction designs. However, HCI lacks appropriate measurement instruments to examine and evaluate experiences with technology in terms of their satisfaction (or frustration) of needs. Instead, researchers and practitioners frequently use measurement instruments developed in (consumer) psychology that are not tailored to the needs of HCI. Here we report on the development of the User Needs Scales (*UNeedS*), a set of scales designed to measure the satisfaction and frustration of 13 fundamental needs identified for HCI, and report on our first experiences applying it. Preliminary data indicate good item qualities and internal consistencies, but further research must substantiate these claims. All scales and the full UNeedS are available in the supplemental materials.

CCS CONCEPTS

• **Human-centered computing → HCI design and evaluation methods**.

KEYWORDS

Questionnaire, user experience, psychological needs

ACM Reference Format:
Sara Wolf, Franzisca Maas, Pauline Künzl, Anna Hohm, and Jörn Hurtienne. 2022. UNeedS: Development of Scales to Measure the Satisfaction and Frustration of 13 Fundamental Needs. In *Mensch und Computer 2022 (MuC '22), September 4–7, 2022, Darmstadt, Germany*. ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3543758.3547572

MuC '22, September 4–7, 2022, Darmstadt, Germany

1 INTRODUCTION

The fulfilment of fundamental needs such as autonomy, competence, or relatedness is essential to human well-being and advancement [4]. Their importance has been recognized in HCI, where designing for fundamental need satisfaction is a central prerequisite of enhancing the user experience (UX) [8, 12]. This needs-based perspective on UX builds on the idea that a positive UX is more likely when needs are satisfied through interaction with technology [10, 11]. Activities that satisfy needs are experienced as meaningful and pleasurable [22]. Therefore, it is essential for HCI researchers and practitioners to assess whether needs are frustrated or satisfied when users interact with technologies.

Unfortunately, there is no consensus on what needs to focus on when designing or evaluating interactive technologies. Psychological typologies of needs range from a few (e.g., three in [18]) to many (e.g., 20 in [15]), and it is unclear which of these are essential for HCI. In a recent publication specifically focused on compiling a set of needs useful for human-centered design, Desmet and Fokkinga responded to this gap by proposing a typology of 13 fundamental needs [5]. In addition, they provided a range of tools to sensitise designers to these 13 needs and support the early stages of design [5]. However, HCI researchers and practitioners need tools not only for design but also for evaluation. Evaluations are essential if HCI is to truly understand whether developed technologies and interaction designs support experiences that satisfy particular needs and do not frustrate others. However, most of the needs-focused evaluation instruments currently used in HCI (e.g., [22]) are not well suited for HCI-specific evaluations as they only cover a small range of relevant needs and primarily focus on the satisfaction, not the frustration of needs.

In this paper, we report on our efforts to develop UNeedS, a novel set of scales that measure the satisfaction and frustration of Desmet and Fokkinga's 13 fundamental needs [5].

2 THEORETICAL BACKGROUND

In the last two decades, HCI has seen a shift from usability towards (user) experience and emotions, including a focus on fun, enjoyment, well-being, mindfulness, meaning, and reflection [e.g., 1]. Although several theories are attempting to define what good UX

Table 1: The 13 fundamental needs identified by Desmet and Fokkinga [5].

Need	Description
Autonomy	Being the cause of your actions and feeling that you can do things your own way, rather than feeling as though external conditions and other people determine your actions.
Beauty	Feeling that the world is a place of elegance, coherence and harmony, rather than feeling that the world is disharmonious, unappealing or ugly.
Comfort	Having an easy, simple, relaxing life, rather than experiencing strain, difficulty or overstimulation.
Community	Being part of and accepted by a social group or entity that is important to you, rather than feeling you do not belong anywhere and have no social structure to rely on.
Competence	Having control over your environment and being able to exercise your skills to master challenges, rather than feeling that you are incompetent or ineffective.
Fitness	Having and using a body that is strong, healthy, and full of energy, rather than having a body that feels ill, weak, or listless.
Impact	Seeing that your actions or ideas have an impact on the world and contribute to something, rather than seeing that you have no influence and do not contribute to anything.
Morality	Feeling that the world is a moral place and being able to act in line with your personal values, rather than feeling that the world is immoral and your actions conflict with your values.
Purpose	Having a clear sense of what makes your life meaningful and valuable, instead of lacking direction, significance or meaning in your life.
Recognition	Getting appreciation for what you do and respect for who you are, instead of being disrespected, underappreciated or ignored.
Relatedness	Having warm, mutual, trusting relationships with people who you care about, rather than feeling isolated or unable to make personal connections.
Security	Feeling that your conditions and environment keep you safe from harm and threats, rather than feeling that the world is dangerous, risky or a place of uncertainty.
Stimulation	Being mentally and physically stimulated by novel, varied, and relevant impulses and stimuli, rather than feeling bored, indifferent or apathetic.

is, a widely used perspective focuses on the satisfaction of human needs as the underlying mechanism [10]. This perspective suggests that good interaction is equal to need-satisfying interaction; thus, good interaction design aims to design for need satisfaction [12]. Besides need satisfaction, identifying and preventing need frustrations is equally important [5]. Need frustration is more than just low satisfaction or a lack of it: it can cause discomfort, defensive behaviours, and even psychopathology [3, 19, 23, 24]. Thus, good interactive technologies not only help people to satisfy their needs but also try to avoid triggering need frustration.

However, the range of needs to focus on in HCI design and evaluation differ between studies and research contexts. Drawing on psychological research, HCI often adopts the three-needs model of self-determination theory (autonomy, competence, relatedness [18]) or a ten-needs model (e.g., [10, 22]). A widely used UX questionnaire, the AttrakDiff, only focuses on two needs (stimulation and identity) to define a product's *hedonic quality* [9]. To unify the different perspectives, Desmet and Fokkinga recently suggested a theory-inspired typology of 13 fundamental needs (see Table 1) based on the collection and analysis of existing need typologies and theories such as the ones mentioned above. This novel typology tries to (1) cover the entirety of the concept where each need represents a unique part of the whole, (2) formulate all needs at a common level of abstraction and specificity, and (3) provide a reasonable level of granularity (not too small and not too broad) [5] and is, therefore, the best basis for further HCI research in the context of fundamental needs. While the typology expands our perspective on what needs to focus on in human-centered design, respective evaluation instruments are still missing. Evaluation is essential, for example, to determine whether it is possible to reliably target a design to satisfy or avoid frustrating specific needs and, if so, how best to do it. In addition, it is unclear whether Desmet and Fokkinga's typology of 13 needs compiled from the literature corresponds to users' actual experiences with technology [5]. While HCI currently adopts and adapts scales from (consumer) psychology (e.g., [10, 18, 22]) to measure the satisfaction of needs, these scales neither cover need frustrations nor the 13 needs [5]. In addition, the scales were often developed in English-speaking countries and pragmatically translated to German, which led to items that poorly match "how German users speak" [10].

We, therefore, saw the need to develop a novel instrument for measuring the satisfaction and frustration of the 13 fundamental needs. In the following, we describe the development of the User Needs Scales (UNeedS) that (1) allow measuring both need satisfactions and frustrations, (2) cover the wide range of 13 fundamental needs [5], and (3) comply with good item quality standards.

3 DEVELOPING THE USER NEEDS SCALES (UNEEDS)

To develop the initial version of the UNeedS, we followed a standardized procedure [14]. The core development team consisted of five researchers (four female, one male) with experience in HCI (all) and psychology (two). As the development of the scales coincided with the COVID-19 pandemic, we used an online whiteboard tool

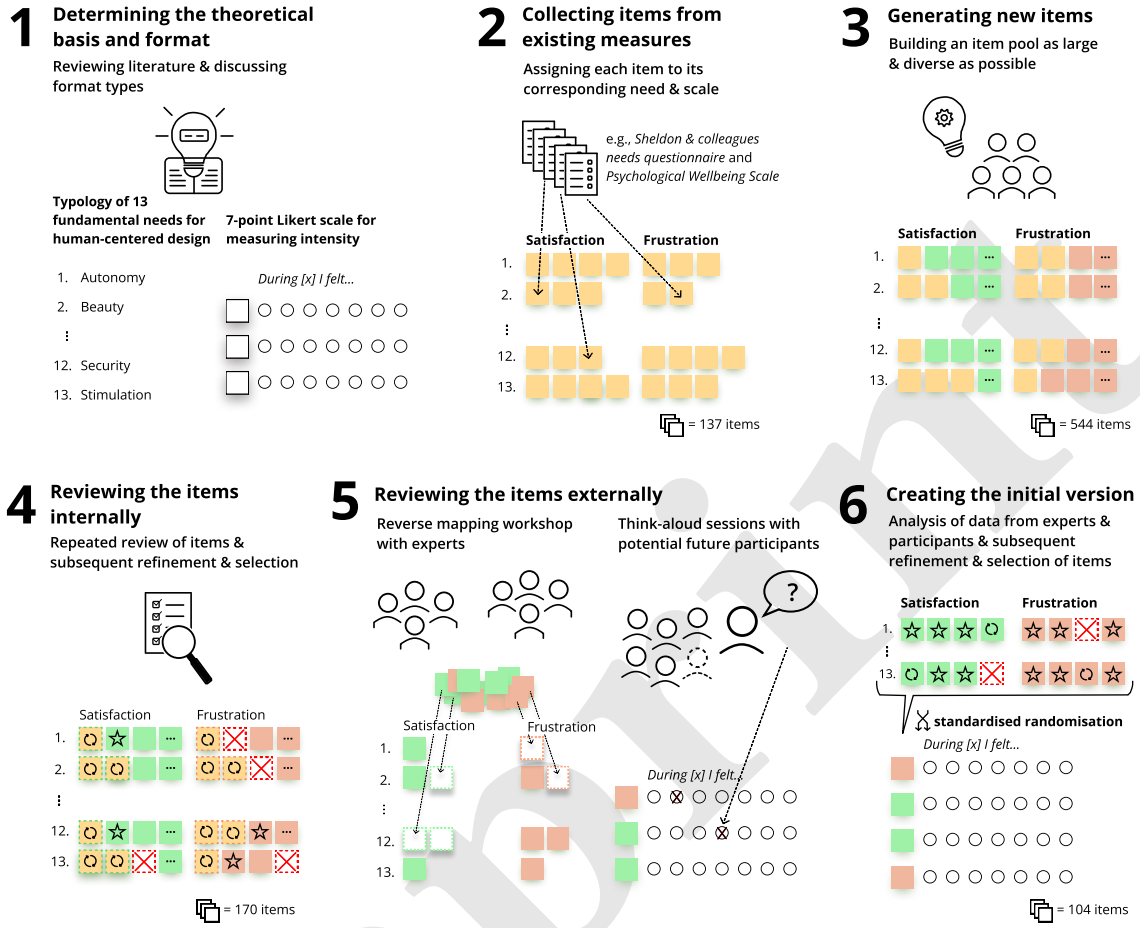

Figure 1: Overview of the major steps in developing the initial version of the UNeedS.

(miro) to facilitate our work and documentation. In the following, we describe the steps of developing UNeedS. Figure 1 summarizes and visualises the development steps.

Step 1: Determining the theoretical basis and format. We used the typology of 13 fundamental needs by Desmet and Fokkinga (see Table 1) as our starting point to develop an HCI-specific measurement instrument [5]. The instrument should cover need satisfaction and frustration, as both are equally important for HCI research and design. Therefore, a set of 26 scales is targeted. After reviewing and discussing various questionnaire formats, we selected intensity scales given that a clear idea of the strength of the characteristic expressions can be developed and there is usually a high degree of behavioural or experiential proximity to the item [14]. In addition, we decided that 7-point Likert scales that verbally express intensity are the best option [6]. Instead of formulating full statements, we decided to use a split sentence question-item format to reduce text. Overall, the potential items of the novel instrument should refer to specific states triggered by the satisfaction or frustration of a need that participants could answer by indicating the intensity with which each was present.

Step 2: Collecting items from existing measures. As a second step, three team members reviewed existing needs questionnaires and scales. We directly assigned suitable items to specific scales and adapted the items if necessary (e.g., translated them to German). Overall, we collected 137 items from [2, 3, 10, 13, 16, 17, 20, 22, 23].

Step 3: Generating new items. As the collected item pool was far from complete (e.g., items for specific need scales were lacking, particularly for the need frustration scales), all team members developed additional items. After immersion into Desmet and Fokkinga's need descriptions [5], we generated new items by finishing the split sentence question "During [X] I felt..." with expressions, building on top of each other's associations. We extensively discussed our understanding of the items' meanings and their fit to the designated scale. In addition, we consulted dictionaries and synonym finders to broaden our initial set of possible items and expressions. We also discussed different HCI scenarios in relation to the items to evaluate the items' fit and generalisability. Everyone worked together for the first few items to ensure a common understanding of the task and procedure. Then, we split into smaller groups to generate additional items more efficiently. For three weeks, all team members continued to generate items individually or in smaller groups until we could not find any new items. In a final meeting, we discussed and solved issues such as having trouble generating items for needs that are harder to grasp (e.g., beauty). Overall, we

generated 407 novel items leading to an overall item pool of 544 items.

Step 4: Reviewing the items internally. In order to reduce the item pool to a manageable set with the best items, all team members reviewed the items for themselves for two weeks and commented on their fit and potential problems. These comments were discussed in a brief meeting, and team members adapted their assessment individually during the following two weeks. Based on the items' ratings and comments, two team members then sorted all items of each scale from best to worst. Each scale ended up consisting of five to ten items. The two team members then reviewed these items individually concerning their match to good quality criteria including aspects such as the semantic content (e.g., formulating simple statements, only one statement per item), linguistics and grammar (e.g., translating concepts into the language of potential participants), or human information processing (e.g., readability and clear design of the items) [14]. In the final meeting of step 4, all team members reviewed, discussed, adapted, and approved the reduced set of items that built the basis for creating a preliminary version of the UNeedS. This version contained 170 items, all of which were new or adapted, and none were directly taken from existing questionnaires.

Step 5: Reviewing the items externally. To further reduce the item pool and double-check the scales' content validity and comprehensibility, we conducted think-aloud sessions with potential future UNeedS participants and a reverse mapping workshop with external experts. We implemented the preliminary version of the UNeedS in LimeSurvey and performed six online think-aloud sessions with potential future participants to test the items' comprehensibility. The participants were, on average, 22.83 years old (SD_{age} = 2.4); three were male, and three were female. Five participants were students of various subjects, and one was in his final school year. All participants received a link to the survey, and after giving consent to the study's procedure and data handling, they were asked to either document a positive or negative experience with interactive technology. The next page then displayed the preliminary UNeedS version. We asked participants to share their screen and think aloud while reading and answering the items. The study facilitator took notes to capture the participants' comments. At the end of the survey, we asked participants for some general comments (e.g., what was complicated to understand?). Overall, most of the participants' comments referred to only a few problematic items that were difficult for all participants to understand.

The second activity, an online reverse mapping workshop, was facilitated by a shared miro-board. All participants (six HCI researchers and two HCI master students) were familiar with needs-based UX and need theories but worked on different topics within HCI, such as intuitive use, emotions, or safety-critical systems. We separated the group into two teams with equal expertise in HCI and needs theories. Each team received a mixed version of the item pool and was asked to (1) reverse-map these items to the respective scales; (2) score each item according to whether it fits the need's definition and the scale; and (3) to discuss what was missing or needed to be changed. The reverse mapping activity led to the identification of items difficult (or impossible) to assign, an assessment of each item's value to the respective scale, and some overarching comments.

We merged the results from both activities so that for each scale, we had a ranking of items, comments on individual items, and a clustered collection of general comments.

Step 6: Creating the initial version. To further reduce the number of items per scale and incorporate what we learned through the reverse mapping and think-aloud sessions, the whole team took two weeks to review the results individually and mark aspects for discussion. During the subsequent meeting, we discussed marked aspects and adjusted items if necessary. We then reviewed all scales again and reduced each scale to four items based on the ranked order, preferences, and content considerations (e.g., preferring items that covered different aspects of a need). We chose this number of items to keep the UNeedS as a whole applicable without tiring participants with the sheer number of items while retaining the possibility for potential further reduction of items through later data analysis.

In a last step, we applied a standardized procedure to create the initial version of the full UNeedS integrating all items of the 26 scales [14]. First, the scales were arranged in random order. Second, one item was drawn randomly from each scale in turn and set in the previously determined order. Third, the order of the scales was again randomised. Fourth, the next items were drawn one after the other and again included in the overall instrument in the previously determined order. This procedure was repeated until all items were arranged. We produced a printed and a digital version of the full UNeedS (see supplemental materials), taking into account participants' comments from the think-aloud sessions, such as more frequent repetition of scale labels and best practice guidelines such as font size suggestions [14].

4 INITIAL APPLICATIONS: AN OUTLOOK AND SUGGESTIONS FOR APPLYING THE UNEEDS

We are currently gathering data to validate the initial version of the UNeedS in two studies on (positive) experiences with interactive technologies and experiences worth telling. Moreover, other labs that already use the UNeedS and we are currently using individual scales in various contexts such as interactive exhibition artifacts, virtual reality experiences, religious communication, driver experiences, and education. In each context, the scales are chosen based on which need satisfactions or frustrations are particularly interesting regarding the research questions.

Although all data collection is still ongoing, we took a first look at the most extensive data set based on our study of experiences with technology worth telling (N = 230; M_{age} = 21.55; SD_{age} = 4.01). Following an adapted critical incident procedure [7, 10], participants described an experience with interactive technologies worth telling and subsequently evaluated their experience using the full UNeedS. While the data set is still too small to perform and report a full exploratory factor analysis, we can provide first insights into the quality of our items and scales. Although we deliberately asked for experiences worth telling to capture both positive and negative experiences, only a few experiences were negative (8%). This implied low need frustration scores and non-normal distributions of responses for all frustration items in the overall data set. Nevertheless, negative experiences were associated with higher frustration scores compared to those reported for positive experiences, which

aligns with our expectations. Responses to the satisfaction items were mostly normally distributed and the scales achieved a high average Cronbach's α of .828, from *comfort* .685 to *competence* .899, indicating solid internal consistencies.

Regarding the application of the UNeedS, we recommend using the full scale if there is little knowledge about the experiences to be researched or when an experience is to be broadly explored. It is also possible to use individual scales of the UNeedS. Based on our experience, applying specific scales helps evaluate a technology designed to satisfy (or avoid frustrating) a particular need. Overall, the UNeedS is designed to measure the satisfaction and frustration of fundamental needs retrospectively. We suppose the UNeedS will usually be used after the experience to be evaluated. However, if not, we recommend asking users to recall the experience and, if possible, report it verbatim before answering the items. This is essential as we generated items that represent felt experiences. The scales' language is not explicitly adapted to the technology context and might be used for experiences of any kind – similarly to other needs-based questionnaires (e.g.[10, 22]). This is supported by the fact that we have not run into issues while using it in a survey on religious blessing experiences that did not necessarily involve technology. From the participants' rich responses to the items in our think-aloud sessions, we learned that the UNeedS could also be used as a conversation starter to inquire about participants' needs in interview situations. Therefore, we believe that the UNeedS can help to explore yet unknown experiences with technology when used in combination with qualitative methods.

5 DISCUSSION AND CONCLUSION

In this paper, we presented the development of the UNeedS, a set of scales to measure the satisfaction and frustration of fundamental needs. Using the 13 fundamental needs for human-centered design as a starting point [5], we built up a large item pool and selected the best potential items through internal and external refinement. The resulting initial UNeedS consists of 26 scales with four items each. We chose this number of items because it is still applicable as a whole without tiring the participants with the sheer number of items, and at the same time, leaves open the possibility of deleting items that prove problematic in the analysis of the data being currently collected.

Practitioners applying the UNeedS can either select individual scales that fit their research question, context, or domain or apply the entire instrument. The former approach corresponds to the modular structure of other UX questionnaires (e.g., [21]) and reflects the expectation that some needs will be satisfied (or frustrated) more often than others in specific contexts. For example, purpose and morality may be more likely to be satisfied in religious technology experiences, while competence and autonomy are more likely to be satisfied in socio-technical work contexts such as acute care or aviation. To gather initial data and test such assumptions, the UNeedS and its individual scales are currently being used in several studies, covering diverse contexts such as interactive exhibition artifacts, technology-mediated teaching-learning scenarios, or experiences with technology worth telling. UNeedS seems to have hit a nerve, as several researchers have already requested access, although final validation is still pending. A first look into the data collected so far revealed good normal distribution and a high average Cronbach's α of .828 in the satisfaction items and scales. We have not yet collected enough data to report on the frustration scales but are currently planning further data collection and analysis.

The UNeedS is still work in progress. While we hope to make a valuable contribution to the HCI community and start a discussion towards a standardized tool for measuring need satisfactions and frustrations, the UNeedS should only be applied with the knowledge of its current provisionality. For example, we recommend that practitioners review the items of the scales before applying them to new contexts to ensure that they reflect the intended research question and content (to achieve high content validity). As of yet, we cannot say whether all need satisfactions and frustrations are reliably observable or measurable in experiences with technologies in different domains. The answer to this question is not only interesting from a practical but also from a theoretical perspective: Will the theoretical typology of 13 needs also be reflected empirically? We hope to perform exploratory and later confirmatory factor analysis and present a validated version of the UNeedS once data collection is completed. In addition, we hope to present accumulated results from the various studies and application areas that used individual scales of the UNeedS and provide further suggestions on how and when to use it.

ACKNOWLEDGMENTS

Parts of the research have been funded by the Federal Ministry of Education and Research (BMBF): "Funding for teacher training with a focus on digitalization in teacher training" in the project CoTeach (project number 01JA2020).

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