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Making a difference: Integrating physiological and psychological needs in user description

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Abstract (300-500 words)

Products particularly designed to support physically impaired people often contain for example big buttons in order to remain easy to use and handy for users suffering from diseases like rheumatism, multiple sclerosis or others. There is for example a reported prevalence of more than 31 million people with rheumatoid arthritis in Europe. This condition most commonly affects the joints of the hands. However, the sales volume of specially designed products does not reflect this number of affected people. This discrepancy can result from the design of these products. First of all, they often look very unattractive. In addition, the design itself strongly implies the context of physically impaired people. This fact can lead to negative user stigmatization, which usually makes the user feel uncomfortable. Thus, it seems that subjective quality aspects are from rising importance when it comes to product usage. However, there is a gap between the consideration of physiological and psychological user demands that needs to be filled.

In consequence, this gap is to be closed and both demands are to be taken into account equally. Therefore, better products can be designed for individual people. Especially physically impaired persons, which have a high demand of subjective quality, will benefit from those products. Literature already includes various methods for psychological and physiological user description. Physiologically there are norms, standards or medical tests for instance. On a psychological perspective, several methods like affective priming or the use of semantic differentials allow a better understanding of the user's attitude. Therefore the question arises, whether there are existing methods suitable to consider physiological and psychological needs in combination.

This paper examines, whether there are qualified approaches that can be used to efficiently identify and compare psychological and physiological user needs. Therefore, it also interprets the compatibility between both types of user needs. Thus, this paper provides a solid base for developing a novel and integrated user-centered design approach that efficiently combines physiological and psychological user needs to improve the development of future products.

Keywords: subjective user needs, physiological user needs, user stigmatization, integrated user centered design

1 Motivation and Background

Many people in the world have to deal with physical impairments, whereby people of all ages, genders and races can be affected. Those who are concerned suffer e.g. from the aftermath of an accident or the negative effects of diseases like rheumatism, multiple sclerosis or others. Such disorders are generally associated with sensory or cognitive disabilities as well as pain, stiffness and a decreased range of motion (Arthritis Foundation, 2017; Kister et al., 2013). There are already approximately 31 million people in Europe and around 50 million in the US suffering from rheumatoid arthritis, which most commonly affects the joints of the hands (Arthritis Foundation, 2017; eumusc.net, 2012; Statista, 2017). Those physical impairments usually have a negative impact on product usage. Therefore, there are products particularly designed to support this restricted user group. The products e.g. have big buttons or bulky handles in order to remain easy to use and handy. Figure 1 gives examples of such products like a robust mobile device, a universal remote with a clear layout and a light weighted and easy to grasp scissor.

a) mobile device b) universal remote c) scissors

Figure 1. Examples of products for physically impaired people (Doro AB, 2018; The Wright Stuff, 2018a, 2018b)

However, thinking about the number of affected people there is a huge discrepancy to the sales volume of those specially designed products (e.g. Doro AB, 2016). Considering different explanations, the design itself plays a major role. On the one hand, these products simply look very unattractive so that there is hardly any kind of enthusiasm for the user to actually use the product. On the other hand, the product appearance also strongly implies that these products are designed for physically impaired people. This can lead to negative user stigmatisation no user wants to face. In spite of a high functional utility value, product rejection often occurs. Looking at the universal remote in Figure 1b, it has a good grip, a comfortable handling as well as a clear and understandable structure. From a functional perspective, it is per se an ideal product for people with numb- or stiffness. Yet, it is hard to imagine that e.g. a 30-year-old suffering from a rheumatic disease would be happy to use this kind of remote control.

This example illustrates the upcoming challenges in product design and development: in addition to the basic functionality and ergonomic (physiological) design of products, subjective user needs must also be taken into account. In this context, parallel to the fulfilment of physiological user needs such as good handling and usability, the development of a user friendly and not stigmatising product in terms of subjective quality needs to be focused. Herein, it is particularly difficult to link the perceived subjective quality of a user with certain product characteristics and properties, as this process is hidden inside the user's mind – physiological aspects in contrast are primarily objective and can be detected more easily (Desmet &

Pohlmeyer, 2013). However, we need to close the prevailing gap between the consideration of physiological and psychological user demands and consider both perspectives equally. In order to prevent misleading use of words, the central terms are clarified at this point:

- **physiological user needs**
  Requirements resulting from the physiological (physical) capacity of the user (motoric, sensory and cognitive capabilities as well as anthropometric characteristics) (based on Wickens, Lee, Liu, & Gordon Becker, 2004)
- **psychological (subjective) user needs**
  Requirements resulting from the individual attitude of the user, which significantly influences the value creation of a product ("whether to like a product or not") (based on Zöller & Wartzack, 2017)

Considering the above-mentioned user needs, better products for individual people can be designed. Especially physically impaired persons that have a high demand of subjective quality will benefit from it. To achieve this aim, we first need a dual user description whereas the physiological and psychological user needs form the basis that enables product developers to immediately compare and optimize the subjective and physical quality of a product in the future. Therefore, the question arises whether there are existing methods that are suitable to collect and combine physiological and psychological user needs in the context of dual user description. To identify qualified approaches we look into two different research disciplines. Affective Engineering on the one hand generally addresses the relationship between the physical product design and its affective influence on the users (Schütte, 2007). The discipline of human factors and ergonomics on the other hand deals with and tries to optimize the interactions between humans and products or systems in order to generally face people's needs, abilities and limitations (Karwowski, 2005). Starting at the beginning of user integration, the scope of the paper is not yet to analyze existing techniques for psychological or physiological optimization of products, but to identify different methods to gather physiological and subjective user needs (chapter 2) and discusses their potential for dual user description (chapter 3).

2 Capturing physiological and psychological user needs

The upcoming sections introduce a variety of different methods to capture physiological and psychological user needs in the context of product development. Chapter 2.1 first addresses the physiological user description, whereas chapter 2.2 focuses on the subjective perspective.

2.1 Methods to identify physiological user needs

As mentioned in chapter 1 the physiological capacity of the user, i.e. their physiological needs in product development, consists of motor, sensory and cognitive abilities as well as anthropometric data, which represents the basic framework of ergonomic considerations in product development. In these areas, literature contains a wide range of databases, standards and guidelines. Many of them do not include the actual capturing of physical data. Instead, they often give definitions or an overlook with general or specific recommendations on how to model products in an ergonomic context (e.g. Biermann, Weißmantel, & Pöser, 1997; VDI, 2016). Besides, various standards and guidelines exist that focus on anthropometric data and how to collect and measure them (DIN, 2008, 2017). Those standards give information on essential anthropometric measures differentiating between standing and sitting persons (e.g. shoulder or sitting height), individual body parts (e.g. flexed forearm grip, sagittal arc) and functional dimensions (e.g. distance between elbow and handle axis, length between forearm and fingertips). The measurement methods and which instruments are needed are also explained in

detail. During the measurements, a defined and straight body position is requested. Due to a strong dependency on age and gender as well as a high individual variability of the test persons, a comfortable posture is excluded in order to ensure the comparability of the databases (DIN, 2008). The most common instruments to measure anthropometric data manually are illustrated in Figure 2a.
It can also be measured automatically with a 3D body scanner (Figure 2b). For this method, normally a variety of different lasers is used, that project a horizontal layer on a subject's body, which then moves from top to bottom. In combination with a camera, the geometry of the whole body is captured as a 3D point cloud. Using different algorithms anthropometric data can be extracted thereof. (Mühlstedt, 2016) However, especially when deriving anthropometric data of smaller body parts such as the hand, problems can occur due to a low resolution of the scan (DIN, 2010).

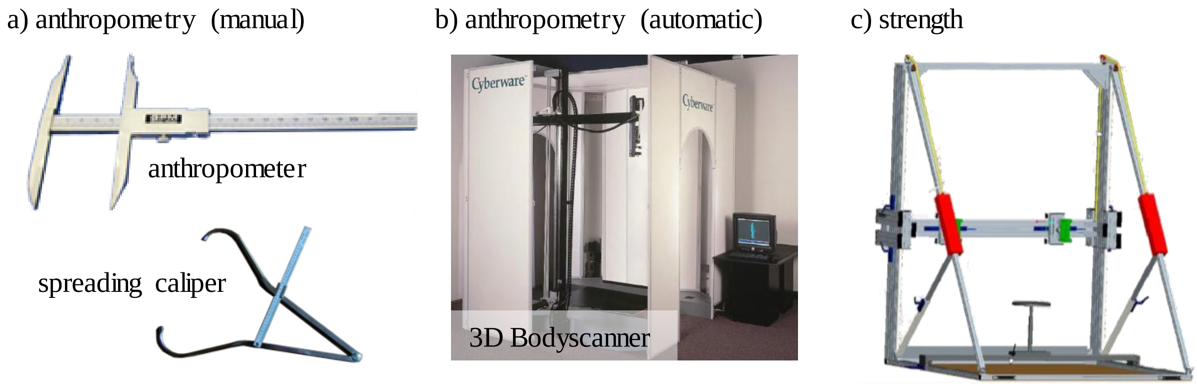

Figure 2. Examples of instruments to measure a) anthropometric data manually or b) automatically as well as c) the strength of the human body (DIN, 2017; Hotzman et al., 2011; Wakula et al., 2009)

Besides anthropometry, there are also motor, sensory and cognitive abilities we need to pay attention to. They are all related: the sensory system (vision, hearing, taste, smelling and touch) first perceives different information about the environment – the visual sense plays a major role in particular. The cognition now enables the data processing. (Wickens et al., 2004) By processing the perceived information both abilities then form the basis for the functionality of the motoric system and thus of product interaction e.g. the position of the human body and possible interactions with the environment (Weiss, 1998). Especially in the medical field, there are many different tests to efficiently measure those three abilities. At this point, we introduce just a few exemplary tests from the individual disciplines as an overview.
Vision as the essential sensory system in perception can be tested via contrast sensitivity testing (horizontal lines of capital letters with decreasing contrast of the letters each line need to be detected by the test person) or visual field testing (testing the ability to fixate a target object while one eye is covered) for instance (Wall & Sadun, 1989).
Measuring cognition can for example be realized with questionnaires. The “mini-mental state”-exam introduced by Folstein, Folstein, and McHugh (1975) is one of them and strictly reduced to only a few relevant cognitive aspects. First, the participants have to vocally respond to questions that cover orientation, memory and attention. Second, they have to write a sentence spontaneously, copy a complex polygon and follow other commands. Finally, a point scale is used to quantify the cognitive abilities.
According to Bös and Mechling (1983) motor skills are defined as the entirety of all human control and functional processes that are based on motion sequences. It can be divided into endurance, strength, speed, coordination and mobility. Therefore, it is very important for product usage. Wakula et al. (2009) focus on the strengths of the human body. To measure the thrust forces a person can apply, the researchers developed a mobile and modular force-

measuring frame (Figure 2c). To measure the strength, triaxial piezoelectric force sensors are used. By adjusting two constituted handles, many different contexts can be represented. Sport motoric tests as an alternate motoric measurement technique focuses primarily on the disciplines endurance, coordination and mobility. The test persons need to work out different individual tasks like performing the one-leg stand to judge one's balance, trunk bends to rate the stretching capacity or riding on the bicycle ergometer with increasing load to evaluate the endurance (Starker et al., 2007). The questionnaire for recording the motoric function status developed by Bös et al. (2002) is another alternative. Here, the respondent has to decide spontaneously how well he or she can solve a given task (e.g. tying shoes while standing). Depending on whether the interviewee is not able to perform the activity at all (1 point) or without problems (5 points), he or she receives one to five points. At the end, the points are cumulated and provide an overview of the performance level of the participant.
The general intention of measuring the physiological performance of a person with physical tests is to provide an objective and quantitativ statement. However, a complete decoupling from psychology cannot be achieved. Questions about the perceived physical exertion for instance are often strongly subjective and depend on personal perception. The as little perceived exertion of an athlete might be an insurmountable challenge for a less trained person, even if it's the same activity. Factors like intrinsic/extrinsic motivation, the prevailing mood or personal experiences also influence the viligrane interplay between psychology and physiology and once again underline the importance of combining the two perspectives rather than decoupling them.

2.2 Methods to identify psychological (subjective) user needs

Focusing on psychological user needs in product development, the attention often lies on the perceived emotions while reviewing a product (e.g. Desmet & Pohlmeyer, 2013). In this context, methodical approaches both refer to addressing and evoking the "right emotions" as well as providing assistance in transferring those emotions to the design of the product (see e.g. Desmet, 2002; Jordan, 2002; Norman, 2005). There is no doubt that emotions are extremely important in subjective product evaluation. Therefore, it is not surprising that there are in fact many methods to measure them. However, looking at those do not give a general insight on the actual subjective user needs the product developer needs to satisfy. To achieve this aim we rather need to identify the subjective expectation a person has towards a product or its usage. To do so various psychological principles like human behavior, motivation or personality need to be considered. Within those research areas, numerous models and methods can be found. Questionnaires or interviews – as the standard methodology in psychology (McDonald, 2008) – could be used to simply ask people directly for their subjective aspiration for instance. However, we assume that such an open-minded task does not lead to high-quality results. There might be a strong dependency between the quality of the answers and the communicativeness of the respondent. It is not sure whether subjective user needs can be properly collected as well as how distinct the quantifiability of the answers is.
To overcome those challenges and create a stronger context to product development we can use the fact that people like to express themselves through objects (Hassenzahl, Burmester, & Koller, 2003). In psychology, we call this the concept of product-personality congruency. It means that a person likes a product when the personal attitude and value are consistent with the perceived quality of the product (Sirgy, 1982) (Figure 3).

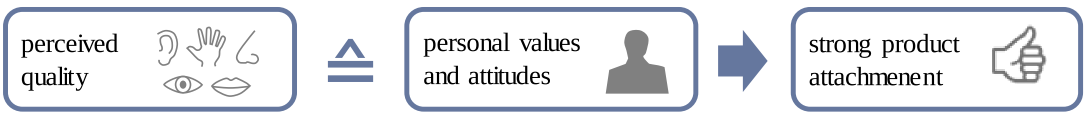

Figure 3. The concept of product-personality congruency (according to Sirgy, 1982)

Thus, the individual attitude of the user significantly influences the value creation of a product, which makes it an important factor to consider in the process of product development and therefore will be focused on in this paper. The question that arises now is how the personal attitudes of a person can be measured effectively. Considering different psychological approaches, there are generally two possible options: direct or indirect measurement. The most common methods for indirect attitudes measurement is affective priming and the implicit association test (Wentura & Degner, 2006).

Within the affective priming methodology, the test person sees selected words, the so-called targets, which they have to classify as positive or negative by pushing a button. Before that, the person gets a different stimulus like an image or another word. This impulse is called prime and should be ignored by the participant (i.e. no classification is needed). With analysing the reaction time of the classification process, it is possible to make conclusions about the personal attitude of the test person. This is because the more distinct the prime matches with the target, the faster the reaction time will be. In case the word *friendly* represents the target for instance, it would be rated positive more quickly if the word *nice* is the prime and slower if *ugly* emerged as the stimuli. (Fazio & Olson, 2003)

The implicit association test is another indirect method to capture the attitudes of a person without prejudice. Within the test, there are two reaction buttons, each of them is assigned with two different elements (e.g. left key: *positive* & *healthy*, right key: *negative* & *unhealthy*). The test person is shown various words that need to be assigned to the elements by pushing one of the reaction buttons (e.g. pushing the left button while seeing the word *lettuce*). During the test, the assignment of the buttons changes (e.g. from left to right and vice versa) and mixed up (e.g. left key changes to: *negative* & *healthy*, right key: *positive* & *unhealthy*). Similar to the affective priming the reaction time gives information about the personal attitude, whereas a faster reaction time occurs when the investigated elements (e.g. *positive* & *healthy*) are strongly related to the subject's point of view. (Wentura & Degner, 2006)

As an alternative to indirect measurement methods, attitudes can also be captured in a more direct way through questionnaires or self-information sheets (Robins, Tracy, & Sherman, 2016). For this purpose, various rating scales like Likert scales or semantic differentials can be used (Figure 4). Whereas semantic differentials are more reliable due to the more precise understanding of the interrogated words (Zöller & Wartzack, 2017).

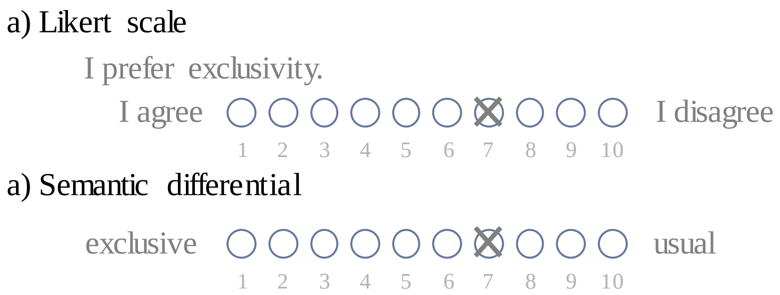

Figure 4. Example of a) the Likert scale and b) semantic differentials (according to Zöller & Wartzack, 2017)

Frey (1993) examined that attitude can be divided into seven dimensions: value, time, particularity, aesthetic, atmosphere, trust and superiority. Those can also be subdivided into different attributes as well (e.g. exclusivity referring to value, elegance referring to aesthetic, complexity referring to trust and so on). Frey identified a total of 30 attributes and specified the corresponding opposites to mount semantic differentials. Questioning a test person all of them results in the so-called impression differential consisting of the 30 semantic differentials that refer to the seven attitudinal dimensions.

In this section, we introduced different techniques to measure intangible user attitudes, whereby also quantitative approaches were mentioned. The following section will now discuss the potential of both the physiological methods as well as the psychological techniques to measure attitudes and physiological performance in terms of dual user description.

3 Discussion of the potential of existing methods for dual user description

The long-term aim of dual user description is to form the basis to design, optimize and evaluate products in terms of a subjective and physiological perspective and therefore to capture the user efficiently with all his facets in the context of product development. Accordingly, a product developer with a primary technical background and without further knowledge in ergonomics and psychology will most likely apply such methods. Therefore, complex measurement techniques are not the instruments of choice. Instead, the measurements should deliver robust results as well as be manageable with only little effort.

The introduced indirect methods to capture subjective user needs, in particular the user's attitude, do not fulfil those requirements. They are very complex and difficult to master by a non-expert. Due to the lack of knowledge, it is very challenging for them to elaborate a suitable test setup and accurately analyse the reaction times afterwards. While using the product-personality congruency it is also practical to measure not only the user's attitude but also the subjective quality of a product with the same method. That makes it easier to analyse and transfer the subjective requirements. For that task, affective priming and the implicit association test probably need a time consuming adjustment of the test design and yet do not guarantee a good comparability. An easier and more explicit way of measuring attitudes is the use of semantic differentials. Those are already successfully implemented by Zöller and Wartzack (2017) to evaluate personal attitudes and the subjective quality of a product in a quantitative and comprehensible manner. The herein used impression differentials introduced by Frey (1993) can easily be retrieved via questionnaire and is therefore regarded as a practical solution for gathering subjective user needs for dual user description.

In terms of physiological user description, the most challenging question is: what is of interest regarding the use of a product and therefore what is to be measured. It is particularly important to consider the context of product development and to identify and record only the relevant parameters. Thinking about developing smartphones, we need to focus especially on the hand and everything that goes with it but can ignore irrelevant body parts like the feet for instance. Anthropometry alone already provides a large number of measurable parameters. Anyway, skipping their measurement and just using the detailed databases within the standards is not an option. Many of them only consider the 95th to 5th percentile (e.g. DIN, 2008), i.e. normal and healthy people, but consequently exclude physically impaired persons, who are expected to fall out of the recorded ranges. Looking back on the described methods to manually or automatically measure anthropometric data and strength, tools like the 3D body scanner or the force measuring frame are used. Those apparatuses are expensive, require space and are normally very inflexible. A various number of participants need to be identified and appear in person. It would be more efficient if users can participate anonymously and regardless of their location. For this reason, the aim should be to simplify measurement techniques as far as possible and transfer them to objects of everyday life that can be carried out by everyone. Although the accuracy may be slightly reduced, it should still be efficient especially for the early stages of product development. The creation of questionnaires would be a practical solution here. Questionnaires already exist for the measurement of motor, sensory and cognitive abilities (see chapter 2.1). Reducing the scope of the survey to only the relevant measurement variables and supplementing essential anthropometric parameters increases efficiency, in particular the required time for the test. The questions should be easy to answer and remind the

user of everyday situations. Therefore, instead of special devices, strength can e.g. be measured by asking about whether the user can lift only a one-litre bottle or a whole drink crate.
The dual user description should thus be represented by a combined questionnaire with a physiological part on the one hand and a psychological part on the other hand that captures the semantic differentials and therefore the user's attitude. A derivation of key parameters or the traceability of individual measured values from the questionnaire to explicit physiological determinants (like range of motion of the hand referring to motor abilities) would provide a good starting point for the mathematical evaluation of the results. It also adapts the scheme of semantic differentials, which collects the expression of different attributes like exclusivity and lastly refers to different attitudinal values like value or aesthetics. Such a similar assembly and structure ensures the comparability of both the physiological and psychological dimensions and thus results in a standardized user description, user characterization and enables a product evaluation that performs on the same methodical approach as user description.

4 Conclusion and future research

Besides physiological user needs, that are often already be considered in product development, psychological user needs also need to be focused on. Especially physically impaired that have a high demand of subjective quality will benefit from it. Before developing physiological and psychological optimized products we first need to know what physiological and subjective user needs are required. This paper shows various techniques from different disciplines on how to obtain that information. In the end, we recommend to realize the dual user description by using a specially designed questionnaire that contains a psychological part to gather the user's attitude in form of impression differentials and a physiological part to measure motor, sensory and cognitive abilities as well as anthropometric parameters. The introduction of determinants ensure the comparability between the two perceptions. The questionnaire is not yet developed, but will be considered in future research. In the long term, dual user description provides a solid basis for an integrated user-centered design approach that helps product developers to design and optimize products in terms of physiological and psychological requirements as well as characterizing users and products from both perspectives. Future research should now concentrate on developing and evaluating a suitable questionnaire for dual user description in the context of product development. Here, one of the most challenging but not less important aspect will be to identify the relevant parameters on the one hand and how to map them with simple and robust measurement procedures on the other hand. In the long-term perspective, the desired integrated user-centered design approach need to be further designed, developed and validated.

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