Eliciting User Requirements and Acceptance for Customizing Mobile Device System Architecture

Katrin Arning[1,*], Bianka Trevisan[2], Martina Ziefle[1], and Eva-Maria Jakobs[2]

Human-Computer-Interaction Center, RWTH Aachen University
[1] Theaterplatz 14, 52062 Aachen, Germany
[2] Templergraben 83, 52066 Aachen, Germany
{arning,ziefle}@comm-rwth-aachen.de,
{b.trevisan,e.m.jakobs}@tk.rwth-aachen.de

Abstract. Mass customization is a popular approach in product design and manufacturing, where customers can configure standard products according to their individual preferences. Applied to the technical customization of mobile device system architecture (e.g. smartphones), an empirical multi-method approach was applied in order to elicit user requirements and acceptance. First, in a text mining analysis with n=80.995 blog comments relevant components and properties of cell phones were identified. Second, an online-survey with n=48 participants was conducted, which quantified user requirements and acceptance of the customization approach. The consecutive combination of text mining and survey provided valuable insights into user perceptions and acceptance. Customization was perceived positively, although the willingness to pay was low. Customizable technical characteristics in mobile device system design such as battery life, speech quality, memory capacity and connection quality as well as user profiles were identified.

Keywords: mass customization, acceptance, user requirements, survey, textmining.

1 Introduction

Today, customers prefer products, which are individually designed according to their personal ideas and preferences. A popular approach in product design is *Mass Customization*. Mass customization refers to the production of goods and services for a (relatively) large market that meets the diverse needs of each individual consumer of these products [1]. Thereby, customers can configure standard products according to their specific wishes, ideas and needs by choosing from a range of possible product components and designs. From the perspective of the manufacturer, it is possible to achieve a high efficiency of production and distribution in spite of individualization, which comes close to (mass-) standard products. Thus, the customized products are offered at prices that correspond to the willingness of buyers of (mass-) standard

* Corresponding author.

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products. Accordingly, customers can create and purchase a product individually to fair prices. Manufacturers of different products have proved the approach already, especially in the context of apparel manufacturing [2], a famous example of mass customization is the Nike shoe [3].

Although the demand for personalization of mobile devices is undoubtedly large, the customization approach is not yet applied to the technical customization of mobile devices (e.g. smartphones). Up to now, customization or personalization options in mobile devices are restricted to design factors of the interface or cell phone housing such as background images, ringtones, protection covers or the set-up of usage profiles (e.g. airplane mode) are available. However, the potential of customization of mobile device system architecture has not been explored yet, even though technical solutions for a flexible adaption of the system configuration to customers' needs already exist [4]. Recent research on mass customization almost exclusively focused on economic aspects, i.e. how mass customization can be efficiently delivered by manufacturers [5]. Aspects of mass customization acceptance have been rarely considered, even though customers' acceptance is a decisive factor for the market success of product. The issue of acceptance – especially in the context of technology acceptance – has become a key concept in the design and rollout of products. A product has a higher probability to be accepted by customers, if it is perceived as useful and easy to use [6]. Both criteria, usefulness and ease of use, are the central determinants of the Technology Acceptance Model [7], which was developed in the 80ies in order to explain the acceptance of job-related computer usage. However, apart from other critical objections [8], the TAM and its successors [9] are too generic to provide concrete guidelines for the design of customization approaches. Therefore, in a first step, it is necessary to investigate user perceptions in terms of relevant customizable technical features, as well as individual benefits and barriers related to the customization approach. In our paper, we present user requirements and an acceptance evaluation of the customization of mobile device system architecture. First, we identified technical components, which are perceived as relevant for customization by users (e.g., voice quality, camera or weight) und can variably be set up by manufacturers. Second, we quantified user preferences of relevant customizable technical components, and third, we assessed users' acceptance of the customization approach with regard to perceived drivers and barriers. A multi-method approach based on text mining and a survey was applied in order to assess user requirements and acceptance data.

2 Method

An empirical multi-method approach was applied in order to elicit user requirements and acceptance with regard to the customization of mobile device architecture. Two methods were applied sequentially: (1) A text mining analysis with n=80,995 blog comments was performed with the aim to identify relevant components and properties of cell phones. The results of the text mining were used for the selection of relevant technical features in the survey. (2) An online-survey with n=48 participants was conducted, which assessed user requirements regarding mobile device system architecture and users' acceptance regarding the customization approach.

2.1 Text Mining

Text mining refers to the (semi-)automatic content analysis of weakly structured or non-standardized contents (= texts), such as e-mails, newspaper articles or web comments in large text corpora, using statistical (quantitative) and linguistic (qualitative) methods of Information Retrieval (IR), Information Extraction (IE) and Natural Language Processing (NLP) [10], [11], [12]. Thereby, the application of text mining to web texts is called *Web Mining*. The aim of the methodology is to identify key-topics, topic relations and topic evaluations. The method is adapted from market and opinion research, where it is mainly used for product reviews.

Text Analysis. The study focused on the identification and analysis of evaluation-relevant cell phone components. Therefore, an explorative text analysis was performed using the software PASW Modeler 13. The blog comments were analyzed in a two-step procedure: (1) for frequency, to identify the most often mentioned items, (2) for co-occurrence or sentiment, to determine how the as relevant identified items are evaluated.

1. As a result of the frequency analysis, 25 relevant cell phone components were identified that were discussed and evaluated often in the respective comment corpus. These items are: battery life, camera, connection quality, connection stability, data rate, design, device size, display readability, display reflection, display resolution, display size, energysafe mode, exchangeability of the battery, Internet access, latency, memory capacity, radiation (SAR), reliability of the data transfer, robustness, speech quality, standby time, synchronization with PC, throughput, touchscreen, weight.
2. For each of the 25 items it was analyzed, how often they are evaluated positively or negatively in the Web comment corpus. For this purpose, the corpus is searched and analyzed based on allocation rules. The allocation rules (see example (1)) consist of a) relevant words of the semantically related word field (e.g. for the item battery life the synonym battery runtime) and b) links to word lists which contain positive and negative connoted words. For this analysis, iPhone as a synonym of cell or smart phone has been excluded. The rule states that the terms cell phone, battery and life must occur together in a sentence and have a negative sentiment.

(1) <cell phone> & <negative> & <battery> & <life>

Corpus. For the present study, a corpus of a topic-specific German blog dealing with MCS was selected and blog comments from the year 2009 elicited. In total, the corpus contained 80.995 blog comments. In a number of preprocessing steps, comments are bowdlerized from enclosing webpage elements and html-tags and corresponding meta information, e.g. user name is extracted and added as meta data to the comment. Table 1 illustrates some statistics about the corpus collection, particularly in terms of covered users and their blogging frequency.

Table 1. Comment corpus statistics

	Data 2009
Articles	1.289
Comments	81.831
Users	9.509
#Comments per article	63
#Comments per user	9

As commonly known, the blog *Heise.de* is a playground for high-potential users. Here, users interact with each other; these users are very familiar in the area of mobile communication systems. Users, who want to find out about pros and cons of a mobile device, search for information in this blog.

Statistical Analysis. The identified cell phone components or items were sorted and ranked descending automatically according to positive and negative polarity. The ranking demonstrates which item was discussed most frequently in which manner by bloggers. High listed entries dominate the bloggers talk.

2.2 Survey

Surveys are one of the most extensively used empirical research methods in information systems and technology acceptance research [13]. Based on the findings of the text mining study and on expert input, a user survey was conducted in order to identify and quantify the most relevant technical characteristics of mobile devices and customization acceptance from the users' perspective.

Questionnaire. The questionnaire was structured as follows: the first part assessed demographic characteristics (age, gender, profession, mobile communication equipment and usage behavior (duration, frequency)), the second part asked for purchase-relevant technical characteristics of mobile devices, the third part assessed participants' customization acceptance as well as drivers and barriers of customization acceptance. Questionnaire items had to be confirmed or denied on a six-point Likert scale ranging from "1 = totally unimportant" to "6 = extremely important" (for the preference ratings of purchase-relevant technical characteristics, questionnaire part 2) and "1 = totally disagree" to "6 = totally agree" (for customization acceptance, questionnaire part 3).

Sample. A total of n = 48 mobile phone and smartphone users between 23 - 62 years (M = 34.0, SD = 11.22, 52% female) took part in the survey. The educational level was comparably high (79.2% held an university degree). Asked for mobile communication equipment and usage behavior, the majority (89%) reported to own and use a mobile phone and/or a smartphone. Almost the half (49%) reported to predominantly use a mobile phone, and 51% reported to mainly use a smartphone. Regarding usage behavior, participants had on average 10.52 years of mobile device usage experience

(SD=3.71). Asked for the usage frequency of their mobile device, 50% reported to use it several times a day, 14.3% use it daily, 4.8% use it 2-3x per week, and 11.9% reported to use it 1x per week. Considering the high experience of using mobile devices in the sample we assume that the participants were able to give valid statements concerning the issue under study.

Statistical Analysis. Descriptive statistics as well as univariate and multivariate analyses of variance were employed. The significance of the omnibus F-Tests in the MANOVA analyses were taken from Pillai values. The level of significance was set at 5%. Due to the sample size, results on a alpha < 0.1 level are reported as marginally significant. In order to study the effects of mobile device type, the sample was divided into two groups according to the mainly used device type: mobile phone users (n=27, 55%) and smartphone users (n=21, 45%).

3 Results

3.1 Text Mining

Relevant Technical Characteristics of Mobile Devices. The results show that the items (1) *memory capacity* and (2) *battery life* are evaluated most frequently (Fig. 1). Regarding item (1), users evaluated the provided memory capacity by the manufacturer as sufficient or positive (n_p=347); contrarily, the other half of the blogger believes that sufficient memory capacities can only be maintain by capacity expansion. They evaluate the provided memory rather negative (n_n=304).

The second highest rated item is (2) battery life. The bloggers evaluate the duration (in hours) of cell phone batteries under normal use (average of calling, Internet usage, etc.) in relation to the battery charging time. Here, a charging time of 3 hours for a 1050 mA battery is classified as "inopportune". Overall, however, the battery life is rated mostly positive (n_p=174, n_n=147).

Moreover, other high-scored items are touchscreen (n_p=56, n_n=13), camera (n_p=22, n_n=52), battery exchangeability (n_p=54, n_n=52), display resolution (n_p=61, n_n=47) and speech quality (n_p=65, n_n=41). Overall, all items are usually equally often evaluated positively or negatively.

3.2 Survey

Relevant Technical Characteristics of Mobile Devices. Based on participants' preference ratings of purchase-relevant characteristics, the most important technical components of mobile devices were battery life, speech quality, connection stability and connection quality. The least important features were latency, camera, radiation (SAR) and brand (Fig. 2).

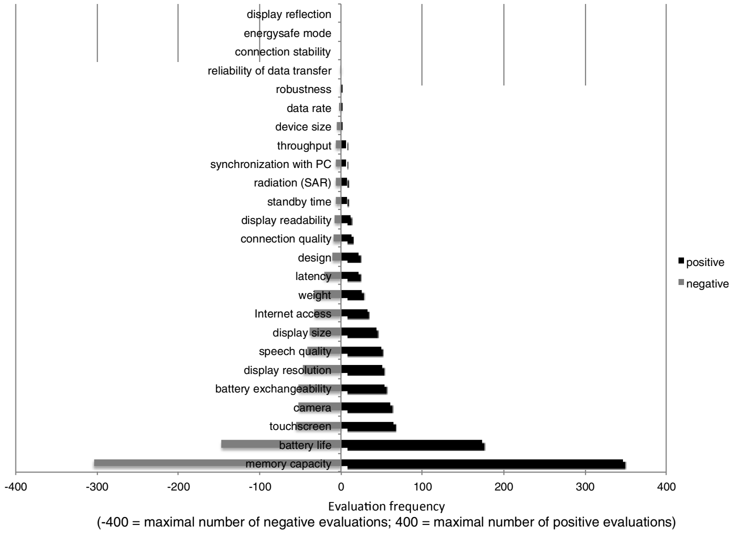

Fig. 1. Relevant technical characteristics of mobile devices (n=80.995); left side: negative polarity, right side: positive polarity

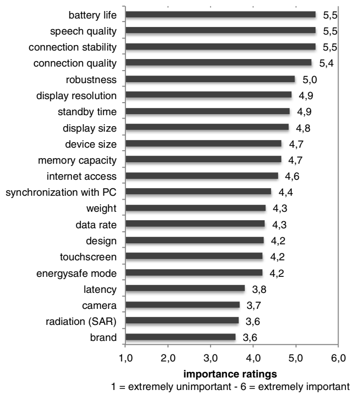

Fig. 2. Importance ratings for relevant technical characteristics of mobile devices (n = 48)

Customization Acceptance. The analysis of customization acceptance revealed a positive perception of the customization approach. Perceived usefulness of customization was M = 4.44 (SD = 1.17, max = 6) and perceived advantageousness was M = 4.29 (SD = 1.09). Participants liked the idea of customizing their mobile device (M = 4.40, SD = 1.35) and to adapt it to own preferences (M = 4.49, SD = 1.38) and usage situations (M = 4.60, SD = 1.46). However, participants clearly prefer one single optimal configuration profile (M = 4.11, SD = 1.29) instead of changing between situation-specific optimal configuration profiles (SD = 3.81, SD = 1.42).

The major *driver* of customization acceptance was improved efficiency (especially for job-related mobile phone usage (M = 5.49, SD = 1.31) and gaming (M = 5.22, SD

= 1.78). Further drivers were the improvement of mobile device performance (M = 5.06, SD = 1.03) and ease of use during the configuration process (M = 5.11, SD = 1.03). In contrast, the potential of reducing mobile devices' radiation was not perceived as a major advantage of customization (M = 3.98, SD = 1.50).
Main *barrier* of customization acceptance were additional costs (M = 2.43, SD = 1.19), i.e. users willingness to pay for customized mobile devices was rather low.

User Profiles. Moreover, different *user profiles* were identified according to mobile device usage characteristics. A user-profile (mobile phone users vs. smartphone users) specific analysis of preference ratings of relevant technical characteristics showed that smartphone users reported significantly higher demands regarding the performance of their mobile device (Table 2). We assume that the differences were caused by "data-driven needs": Smartphone users access the Internet via their mobile device more often and use it for data-oriented functions.

Table 2. Differences in preference ratings relevant technical characteristics of mobile devices for mobile phone and smartphone users

	mobile phone users (n = 27)		smartphone users (n = 21)		
	M	SD	M	SD	p
internet access	3.6	1.6	5.6	0.9	$p < 0.01$
data rate	3.2	1.3	5.3	0.7	$p < 0.01$
display size	4.3	1.1	5.3	0.7	$p < 0.05$
display resolution	4.6	1.1	5.2	0.8	$p < 0.01$
PC-synchronization	3.7	1.5	5.1	0.8	$p < 0.01$
memory capacity	4.3	1.4	5.0	0.9	$p < 0.05$
touchscreen	3.7	1.5	4.7	1.3	$p < 0.05$
latency	3.0	1.4	4.5	1.4	$p < 0.01$

Customization acceptance also significantly differed according to user group. Smartphone users perceived a significantly higher usefulness ($F(1,44) = 6.37$; $p < 0.05$) and advantageousness ($F(1,44) = 5.35$; $p < 0.05$) of customization (Fig. 3.).

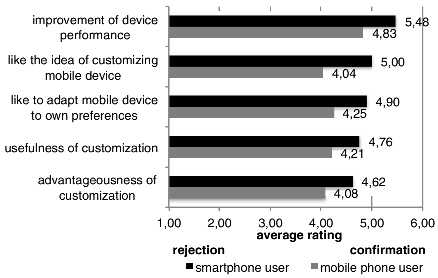

Fig. 3. Differences in customization acceptance for mobile phone and smartphone users

Regarding drivers and barriers of customization acceptance further user group-specific differences were found: General acceptance, measured by perceived usefulness ($F(1,43) = 3.23$, $p < 0.1$) and advantageousness ($F(1,43) = 3.39$, $p < 0.1$), as well as drivers of customization acceptance (improvement of device performance ($F(1,43) = 5.16$, $p < 0.05$), like the idea of customizing ($F(1,43) = 7.26$, $p < 0.01$) and adapting ($F(1,43) = 2.94$, $p < 0.1$) the device to own preferences) were stronger pronounced in smartphone users than in mobile phone users.

4 Discussion

The present study investigated user requirements and acceptance of the mass customization approach in the context of mobile device system architecture. Understanding user requirements and acceptance patterns is essential for a successful design of customization approaches. The following section therefore contains a discussion of results and of our methodological approach, as well as recommendations for a customization approach of mobile device system architecture.

4.1 User Requirements and Acceptance of Mass Customization

In general, we found a positive perception of mass customization, which indicates a high potential of this approach in the context of mobile device system architecture. Moreover, valuable insights into user requirements were gained, which provide a starting point for the design of customization approaches of mobile device system architecture. Relevant customizable technical features from the users' perspective, which were found in both empirical approaches (text mining and survey), were battery life, speech quality, memory capacity and connection quality. Future customization activities in system architecture design should therefore focus on these technical characteristics. Interestingly, users rejected the idea of changing between several system configuration profiles depending on specific situations (e.g. a "gaming configuration" with a high memory and processing capacity at the expense of battery runtime or a "healthy configuration" with low radiation at the expense of low data throughput). Instead of that they prefer one single configuration, which matches the customization approach, i.e. the selection of preferred attributes prior to fabrication far better. Regarding underlying benefits and barriers of customization, users emphasized aspects of improved efficiency and device performance improvements. On the other hand, the willingness to pay for customization of mobile devices was low and represented the single barrier of customization. Accordingly, these acceptance-relevant motives should be addressed in the design of customization systems and in marketing activities. Finally, we found evidence for different user profiles in the survey-data (mobile vs. smartphone users), which showed different preferences regarding customizable technical features and different customization acceptance patterns. The group of smartphone users expressed stronger preferences for a higher data throughput and showed a higher customization acceptance. Compared to that, the text mining data did not allow to extract which users have commented specific technical features. Taking into account comments from different blogs (balanced corpus), might show more concise results about user opinions due to a greater distribution across age and user groups. The shortcomings of the present study are apparent regarding the relatively equal feature evaluation (positive vs. negative, Fig. 1). Therefore, we assume that in a balanced corpus the weighting of cell phone characteristics is more evident. Nevertheless, our studies revealed valuable insights into the users' requirements and acceptance of customizing mobile device system architecture.

4.2 Methodological Approach

The combination of two empirical research methods, i.e. text mining and survey, in the context of eliciting user requirements and acceptance was proven to be successful. Regarding the identification of "top customizable features", both methods provided comparable results (e.g. significance of battery lifetime), which can be interpreted as mutual validation of measurement. On the other hand, both methods also had their specific strength and weaknesses. In the text mining study, for example, it was quantitatively determined which device characteristics are evaluated positively or negatively. More information about users opinions on device characteristics should provide an in-depth analysis, e.g., information on relevant rating scales, characteristic weights, etc. However, an in-depth analysis requires manual data annotation. For this purpose, small and user-specific corpora are needed. Looking at our research approach, we recommend a consecutive application of both methods as most advantageous in the context of acceptance research: The text mining approach is optimal for detecting acceptance-relevant trends in a natural and open environment such as the Internet. The survey, subsequently, which has a more closed and guided focus, is especially suited for taking up previously identified issues, as well as validating and quantifying them.

4.3 Limitations and Future Research

Finally, some limitations and future research directions based on our findings are discussed. One limitation of the text mining method is, that it does not allow yet to derive user profiles. Compared to surveys, where users can be asked for demographic data, user profiles of bloggers stay hidden. However, without demographic data, the circle of involved users cannot be determined exactly. Up to our knowledge, approaches that aim to fix this situation do not exist yet. One way to close this methodological gap could be to guess by some indicators the demographic profile of users, e.g., by metadata (nickname, posting periods) or by comment text (specific expression types). For instance, the nickname can provide hints on users gender (*Bill09*); expression specifics can give information about the educational background (*Cool stuff!*). We consider that an analytical framework for determining user profiles should include analysis categories such as *posting frequency* (allows for the identification of the activity type, active vs. passive user) or *linguistic profile* (refers to users formulation style, colloquial vs. standard style). Future work will deal with the solving of this problem, particularly. Useful methods and techniques can be borrowed from computational linguistics; its usefulness for identification of user profiles has been sketched by Neunerdt et al. [14] already.

A second aspect refers to further steps in the development of customization systems for mobile device architecture. In order to reach broader customer groups for mass customization (e.g. technically inexperienced customers) we suggest the development and evaluation of concrete system configuration profiles (e.g. the aforementioned gaming profile). Moreover, trade-offs between technical system characteristics from the user perspective need to be determined (an example can be found in [15]), in order to support engineers in the development of chip design, which forms the technical basis for the customization of mobile device system architecture.

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