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The Integration of Diverse User Data to derive User Requirements

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Abstract: The user-centered design process demands for the collection of user requirements. Thereby, the process of integrating diverse user data poses several challenges. The aim of our research project AndProtect is to develop a usable tool that provides users a risk evaluation of their apps. Therefore, we captured requirements of smartphone users and applied diverse methods and questioning techniques. For this, we conducted a survey (N = 227) and a user experience assessment (N = 31). Thereby, challenges with regard to the feasibility of user requirements, the consideration of the frequency of responses, and contradictory statements occurred. As a result, we present how we dealt with these challenges and purpose strategies for the requirements integration. Our purposes can guide other researchers, since different methods, techniques and samples commonly used in a user-centered process. Moreover, the discussion on this article could support the identification of new approaches to integrate diverse user data.

Keywords: qualitative, quantitative, user research methods, user experience, mobile application

1 Introduction

Smartphones have become supportive attendants in our everyday life. However, their apps not only deliver useful services and information, they are also able to gather personal information of users [Fe12]. Therefore, self-data protection becomes important for mobile app users. Different approaches are known to support users in protecting their data, e.g., the static analysis, the dynamic analysis or scanning applications [Ge14]. Within the static analysis, the source code of a scanned app is analyzed to detect possible privacy leaks. In contrast, the dynamic analysis explores information flows during a simulated app usage. Within our research project, both analysis methods are combined to enhance transparency on mobile information flows. Moreover, we aim to present these analysis results in a usable scanning App – the AndProtect-App.

As accessibility and comprehension of analysis results are prerequisites for self-data protection, the technical development of the AndProtect-App is accompanied by user research. As a starting point, users' needs and resulting requirements are gathered to ensure a user-centered design [Di11] of the AndProtect-App. Therefore, a survey and a user experience (UX) assessment were conducted.

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2 Methods and Materials

To ensure a user-centered design of the AndProtect-App, we conducted an online survey and an UX-assessment in form of a laboratory study. The survey was performed to gather initial user requirements, whereas the UX-assessment aimed at the identification of requirements regarding the presentation of technical information. Both assessments included closed-ended and open-ended questions. Therefore, diverse methods and diverse question-formats were used. This diversity is also reflected in the nature of participants' responses, which leads to the questions presented at the end of this section.

2.1 Online-Survey

Sample: We received $N = 227$ completed surveys. The majority of the participants (64%) were male and (78%) held a university degree. On average they were 35 years old ($SD = 12.22$). Their smartphone usage behavior was comparable with that of a typical German user. On average the participants used their smartphones $M = 109$ minutes a day ($SD = 100$ min; German smartphone users 140 min/day, [My15]). Furthermore, one quarter of the participants indicated that they had used 11 up to 20 apps, which corresponds to the German average [Fo15].

Procedure: The survey was conducted in spring 2016. Participants were informed about the purpose of the study, that they could cancel the survey at any time and that responses will be anonymized. The participants fulfilled questions pertaining to privacy concerns during the app usage. After that, we asked, „*How privacy protection could be improved in the mobile sector? Do you have requests or ideas for an implementation?*". Furthermore, some demographics (e.g., age, gender, education) and smartphone usage habits (e.g., usage time per day, number of tried apps) were captured. On average, it took about 30 minutes to complete the survey. After completion, the participants had the opportunity to take part in a raffle of 20 Euro payments.

2.2 Laboratory Study: User Experience Assessment

Sample: The majority (65%) of the $N = 31$ participants were female. Their average age was 23 years ($SD = 2.73$). Like in our online-survey, they met the description of typical smartphone users. Participants indicated to use their smartphone $M = 116$ minutes a day ($SD = 65$ min), which was comparable with the average German user [My15]. Like the average user [Fo15], the participants most frequently (29%) had tried out 11 up to 20 applications.

Procedure: The aim of the study was to derive requirements regarding the presentation of technical information. Therefore, some preparations were made in a pre-study. Firstly, the facets of the questionnaire AttrakDiff2 [HBK03] were modified in an explorative process. This modification led to nine UX-facets (e.g., description and valuation of

permissions, options for action, and stimulation). Secondly, three scanning apps were chosen from user-experience experts. After that, we conducted the main study in May 2016. The study took place in a laboratory of Chemnitz University of Technology. Participants` tasks and questions were presented on a PC. Furthermore, a test-smartphone was available to examine the three scanning apps. The participants were informed about the purpose of the study, the anonymized responses, and the possibility to cancel the test at any time. Then, the participants completed three tasks with each of the selected scanning apps (randomized order). Thereby, the scanning apps were used to check information flows of several apps (e.g., Skype, WhatsApp). After completing the tasks of one scanning app, the participants were asked with open-ended questions, if there were any things they liked/disliked during the interaction. When participants had tested all scanning apps, they rated the level of importance of the modified UX-facet (from 1 = "*not important at all*" to 10 = "*extremely important*"). At the end of the study, some demographics and individual smartphone usage habits were captured. On average, the test lasted about one hour and the students received credit points.

2.3 Data Analysis and Challenges of Data Integration

The qualitative responses from the survey (privacy improvements) were analyzed via inductive category formation [Ma14]. Qualitative responses from the laboratory study (like/dislike during interaction with the scanning app) were assigned to the modified UX-facets (deductive category assignment [Ma14]). For the analysis of quantitative data (importance of modified UX-facets), inferential statistics were applied. After these separate analyses, we wanted to summarize the data of both studies. This summary had the aim to derive an integrated set of user requirements for the development of the AndProtect-App. The integration turned out to be challenging in two ways. First, it was difficult to summarize qualitative and quantitative data and second, it was difficult to integrate responses of different used methods. From that, the following questions arose:

1. How could diverse user data be integrated to derive requirements for the development of our tool?
2. Which challenges arise from the integration and how to deal with them?

3 Results and Discussion

This section is divided into two main parts. First, we present our strategy to integrate diverse data (question 1) and second, we show three challenges during the integration process (question 2). Some results of both studies are presented to support the explanations of the strategy and the challenges. Thus, only subsets of study results relevant for the questions above are selected (for further results see [Ha16]; project website: https://www.andprotect.de/veroeffentlichungen/).

3.1 Integration Strategy

To derive holistic requirements for the development of the AndProtect-App, we merged the results of the survey and the laboratory study. Therefore, we used qualitative results from the survey (approaches to improve privacy protection) and the laboratory study (like/dislike during interaction). Thereby, we considered both, content and frequency of qualitative responses. In addition, we analyzed the quantitative data (rated levels of importance of the UX-facets) from the laboratory study.

A general challenge when integrating the results was the different degree of detail. Therefore, our integration strategy was to derive general requirements and to elaborate them with examples for a possible implementation. For example, we derived a requirement to "*provide comprehensive options for action*", which was based on the results of the survey. The supplementary example for an implementation was derived from the UX-assessment. It was formulated as follows "*Provide and highlight the option to delete single permissions or the scanned application within the scanning application*". In this case, the integration was not difficult. In other cases, the integration was challenging, as presented in the section below.

3.2 Challenges

Challenge I - Feasibility of Implementation: On the survey question, how the privacy protection could be improved, the participants made various suggestions. Most frequently (65%), they proposed to strengthen user control to secure personal data (e.g., they wanted to determine, which data were released to whom). Moreover, they asked for more transparency of information flows (15%). Other approaches, such as stricter legal controls or the social change of values, were mentioned less often (< 10%). One challenge was to decide, whether the implementation of the participants' proposals was feasible. For example, this was questionable for the mentioned approaches of stricter legal controls and the social change of values. Of course, our App is not responsible to carry out stricter legal controls. In contrast, the social change of values can be a long-term goal of the project and our App. However, the problem with the approach of changing values was the implementation in the app, because this requirement was too general. In addition, we did not find any further responses that could be assigned to this possible requirement to specify it. Therefore, it would have been either meaningful or speculative to integrate the approach of changing values. Consequently, we decided to drop this proposal when deriving the requirements for our tool.

Challenge II - Frequencies of Mentions: In both studies, we wanted to use the frequency of qualitative responses to indicate how important ideas of participants were. Thereby, the challenge was the handling of rare responses. To illustrate this challenge, we used some survey results. The most responses could be assigned to the approach of strengthen the user control to secure personal data (65%). To increase transparency was mentioned less frequently (15%). However, we interpreted increasing transparency as a logical

prerequisite for strengthen the user control. Probably, the frequencies resulted, because strengthen the user control to secure personal data was easier to retrieve as increasing transparency. Therefore, we concluded that frequencies of mentions are useful to get an overview on qualitative responses, but rare mentions can be as important as frequent mentions. In summary, we used the logical structure of the resulting requirements as decision criteria, when we considered certain user responses.

Challenge III- Contradictory Statements: We investigated which modified UX-facets of the laboratory study were important for the development of our tool. Therefore, we analyzed the frequencies of qualitative responses and the quantitative rated level of importance of one facet. In some cases, the integration was easy, in other cases rather difficult. For example, the results of the facet stimulation revealed contrary conclusions. The third most qualitative answers could be assigned to the facet stimulation. Textual, the most answers refer to the design of core functions of the scanning apps (e.g., the navigation or the valuation of permissions). In contrast, the quantitatively rated level of importance of the facet stimulation was significantly lower (Mdn = 6.00) than the average level of importance of all facets (Mdn = 8.00; Wilcoxon signed-rank test with z = -3.59, $p < .001$). In summary, the qualitative data indicated a high importance, whereas the quantitative data suggested a low importance of the facet. Because of the contents of qualitative responses, we concluded that the facet stimulation was an underlying facet of other facets. Therefore, stimulation may have served to support other facets, which were probably more salient to the user in our UX-assessment. Following this conclusion, we decided to derive a requirement regarding the facet stimulation.

When considering the challenges II and III, in both cases we decided to derive requirements for the development of our tool. In addition, both challenges led to the suggestion of a multilayered requirements structure. However, the reason for the inclusion was different. In challenge II, the increasing transparency was included, because it was a prerequisite for another requirement. In contrast, the stimulation-requirement in this section contributes to the fulfillment of other requirements.

4 Conclusion

In the present paper, we described the user-centered design process [Di11] during our research project AndProtect. Our aim was to present the challenges we faced when integrating diverse user data to derive requirements for our AndProtect-App. Furthermore, we described how we faced these challenges. In addition to these challenges, we see a general challenge in selecting the appropriate methods for holistic user requirements identification. The responses of our participants depended on the two methods we chose. Other methods, e.g., a focus group or a heuristic expert evaluation of scanning apps, would have led to further results and probably to other requirements. Furthermore, as user studies usually rely on voluntary participation, the selection of methods is often associated with different samples. This will lead to selective results as

well. Therefore, two additional questions arose: "*Which methods have to be selected for such an investigation?*", and "*How to deal with the possible bias resulting from the used methods and samples*". During the workshop, we want to discuss these questions and further solution to meet challenges we described above. We hope for a vivid exchange of experiences with other usability researchers.

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