User Interaction Design for Mobile Product Recommender Systems

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Abstract: In this work we present the user interaction design process conducted for a mobile product recommender system that takes the user's critiques into account. The main focus hereby lies on products, where the appearance is important. Smartphones reveal additional characteristics compared to desktop systems being devices that have smaller screens, a direct touch input method and can collect information about the current environment. The interaction model on which the work builds upon is focused on three key interaction activities between the user and the system: the initial preference elicitation process, the presentation of the resulting recommendations set and the preference feedback process. We conduct an interaction design process, involving work on establishing requirements, designing solutions that meet these requirements, producing an interactive prototype of the solution and finally, evaluating it in a two-step process. In total eleven designed alternatives, divided into three groups according to the interaction activities, were evaluated within a user study, showing the advantages and disadvantages of each interaction method.

1 INTRODUCTION

Product recommender systems are web-based tools constructed to ease the process of searching and browsing for items in the vastness of the internet. Critiquing recommender systems allow the user to criticize the suggested items at every recommendation cycle and have proven as an effective approach to elicit the user's preferences and thus to improve personalized recommendations (Lamche et al., 2014). Besides focusing on accuracy in critique-based recommender systems research, the user experience of recommender systems is getting more and more important nowadays (Konstan and Riedl, 2012). A common factor that supports a smooth user experience includes transparency and control management, while also ensuring that the level of cognitive and interaction effort is kept to a minimum (McGinty and Reilly, 2011).

Previous product recommender systems comparing different interaction strategies have heavily focused on conventional desktop-based environments, as in (Pu et al., 2011b) and mostly ignored mobile devices. Although some of the interaction techniques offered on desktop-based systems might be also applicable to smartphones, there are three main challenges to face that do not encounter when designing for desktop systems. First of all, user interaction in smartphones takes place by using specific touch gestures. Second, screen capabilities are drastically reduced, offering not much space for information and navigation possibilities. Finally, since the user is on the move, connectivity problems might occur and the user's attention span is limited as well. This leads to the conclusion that simply overtaking interaction design guidelines evaluated for a desktop system for a smartphone is a rather undesirable approach.

This work will therefore depict several interaction and interface designs for a mobile product recommender system on a smartphone. Since some authors have already investigated interaction design guidelines for shopping products where technical features are important, e.g. (Pu et al., 2011b), our focus lies on products, where the appearance of the item plays an important role. As application scenario therefore serves a mobile shopping recommender system for clothing items. We will also examine the question whether users' interaction preferences stay the same in all circumstances or if they rather change when in a different contextual situation. We will evaluate eleven design alternatives regarding a smooth and pleasing user experience in mobile recommender systems within an online survey and a user study.

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The rest of the paper is organized as follows: We first provide a brief overview of related work and introduce important foundations. We then depict the interaction design process and explain the development of our low- and higher-fidelity prototypes. The following section displays methodology and results of the two-step evaluation. We close by presenting future directions this research topic could take.

2 BACKGROUND

This chapter lays the foundations for the development of an interaction design prototype by explaining basic concepts and summarizing related work.

2.1 Interaction Design for Preference-Based Recommender Systems

Finding a specific item in a large collection of available products can become a demanding task for the user. *Preference-based recommender systems* elicit the user's preferences and suggest items whose attributes match these preferences. By supporting the user in the process of describing, identifying and selecting a user-tailored product to purchase, preference-based recommender systems are not just assisting the process of search, but also the process of decision making. Their main task is to provide effective search and navigation mechanism in guiding users to find their preferred products in e-commerce based on explicitly stated preferences. *Figure 1* demonstrates the interaction model of preference-based recommender systems dispensed in three key activities: The interaction starts with the user describing the item to the system in the form of preferences. Next, the system filters all available options and presents a recommendation set to the user according to these preferences. The user can then revise the preference model by giving feedback on an item in the form of "I like this item, but cheaper" or by rating items that have already been experienced (*step 3* of *figure 1*) as long as the user finds a satisfying item which results in a successful termination of the process (*step 4*) (Pu et al., 2011b). This style of feedback is called *critiques*, and the recommender system class using it *critiquing-based recommender systems* (McGinty and Reilly, 2011).

The *interaction design process* of preference-based recommender systems involves work on establishing requirements, designing solutions that meet those requirements, producing a (interactive) version of the solution, and evaluating it. These activities inform one another and are repeated. Evaluating means including users in the design process, e.g. by developing simple or more comprehensive prototypes which can than be tested by a target group (Rogers et al., 2011).

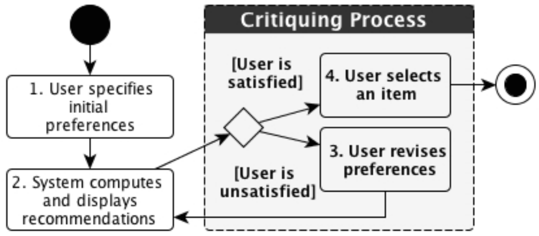


Figure 1: The critiquing process of a preference-based recommender system.

2.2 Related Work

Although disciplines regarding interaction design, such as interface, usability or user experience, are essential parts of the recommender system, there are not many sources in the literature that investigate the mobile interaction design process for product recommender systems. The majority of researches conducted focus on desktop-based platforms, with critiquing as its feedback strategy. Because of the already mentioned limitations and challenges of mobile systems, only few desktop-based recommender systems are adjusted for mobile use.

McGinty and Reilly delivered a comprehensive outline of previous work on interface considerations across critiquing platforms which focuses on scaling to alternate platforms, manipulation interfaces, explanations, visualization and multi-cultural usability differences (McGinty and Reilly, 2011). They denote that "different domain and platform characteristics present recommender interface designers with very different technical and usability challenges" (McGinty and Reilly, 2011, pp. 438).

Pu et al. (Pu et al., 2011b) established a set of eleven usability-guidelines found on the interaction model. They include, among others, how and in which order to elicit the initial set of preferences, how many and which recommended items to present, what to do in case there are no items in the items which match the user's preferences, and so on.

Each of the described works did not focus on the mobile environment. It remains unfamiliar how users would interact on a device with much smaller screen sizes and less keypad functionality in a context-changing environment.

CritiqueShop (Zhang et al., 2008; McGinty and

Reilly, 2011) is an experimental study conducted both in a desktop and mobile environment. The desktop interface has been scaled down to a smartphone. The key considerations aimed at the limited screen area and direct user manipulation via touch-sensitive user interfaces. Their study demonstrated that users are more likely to perform critiques via meaningful icons than via text-based representations, by also reducing the interaction times of a critiquing session (Zhang et al., 2008; McGinty and Reilly, 2011). CritiqueShop was developed to examine critique-based recommender systems on a smartphone, but restricts its feedback strategy to solely critiquing and lacks the context knowledge.

TIP (Hinze and Buchanan, 2005) is a mobile system that delivers information about sights (information objects) based on the user's context: location, travel history and personal profiles describing interest in sight groups and topics. Recommendations are also given based on user feedback and profiles. The paper presents several challenges in the user interface and interaction design. For example, to distinguish between sights that are close and sights that are distant to the user's location and accordingly apply different color schemes (Hinze and Buchanan, 2005). TIP focuses on the calculation of accurate recommendations for a tourist scenario rather than on evaluating different aspects of the user interaction design of mobile product recommender systems.

Focal (Garcin et al., 2014) is a personalized mobile news reader that explores new design ideas to present news stories to the users. News are shown as nodes in a graph and allow the user to quickly determine the freshness, popularity and relevance of a story by varying the thickness of the graphs, transparency and largeness of the nodes (Garcin et al., 2014). A user study that compares this new design alternative to a classical list-view in order to prove its benefits has not yet been conducted.

3 Interaction Design Process

Each of the following subsections describes one step in the interaction design process (introduced in *subsection 2.1*), excluding the evaluation, which is particularly described in *section 4*.

3.1 Requirements Establishment

Based on the interaction model of preference-based recommender systems described in *subsection 2.1*, we can now make rough functional and data requirements to provide high usability and best user experience for each interaction activity.

1. For the task of setting initial preferences, the user can either *explicitly* specify its preferences or alternatively allow the system to automatically collect the user's preferences (e.g. based on the user's browsing and clicking behavior). In this *implicit* way, no user interaction is required.
2. In the second step, the user should be presented one or several items matching the elicited preferences, accompanied by information why this item was elected.
3. The user should be able to select an item from the presented step and either mark it as her final choice, or provide some kind of feedback on the item and/or its attribute values in order to revise her preferences and receive a new set of recommended items.

3.2 Designing Alternatives

Designing alternatives is the core activity of the interaction design: actually suggesting ideas, which meet the requirements. On the one hand, we will hark back to classical interaction techniques that have already been offered on desktop recommender systems to see if they can also be applied on smartphones, on the other hand we will come up with new interaction design ideas.

3.2.1 Setting Initial Preferences

When designing alternatives for setting the users' initial preferences regarding an item, we distinguish between two different preference elicitation techniques: Stating preferences by assigning values to several clothing item features and stating a reference product that is being searched. Design alternatives that cope with the initial elicitation of preferences were developed according to these two techniques: First, manually setting the feature values. Second, taking a picture of an item or uploading an existing one. The system should then recognize some properties of the covered item or find items similar to it based on an image search. A third technique would be an implicit preference determination. *Table* 1 presents the alternatives with an overview of their properties.

3.2.2 Presentation

As response to the user's initial set of preferences from step one, the system has to show either *one* or *several* recommended items fitting these preferences. Additionally, if the system returns multiple items, the

Table 1: 'Setting preferences' alternatives.

	Acquisition Process	**Application Domain Visible**	**Mobile Module Used**
Take Picture	System: Image recognition	No, only in overview	Camera
Upload Picture	System: Image recognition	No, only in overview	Internet Access
Manually Set	Explicitly user: List of attributes	No	-
Answer Questions	Explicitly user: One screen per question	No, only in revision	-
Implicitly	System: User-model	No	Internet Access

questions to be answered are how much items to show and how to lay them out? A *Comparison* presentation interface was in the design stage imagined as an additional feature to directly compare two recommended items. However, it can also serve to present the two best-ranked items to the user. *Table 2* gives an overview of the designed and presented alternatives.

Table 2: 'Presentation of items' alternatives.

	Number of Items Fitting on Screen	**Image Size**	**Visibility of Item Details**
Single Item	1	Big	Complete description
List View	Multiple (≈ 6)	Small	Most of the description
Grid View	Multiple (≈ 3x3)	Small	1 - 2 item attributes
Map	Multiple	Small	Most of the description
Comparison	2	Small	List: attribute -value pairs

3.2.3 Giving Feedback

User feedback (also known as preference revision) is a vital component of most recommender systems, allowing a system to make better suggestions by adapting its current understanding of users' requirements (McGinty and Reilly, 2011). In order to achieve this, several feedback strategies have been developed. Older strategies include *ratings-based* feedback, while changing one or more desired characteristics of a product is the subject of more recent research (McGinty and Reilly, 2011). This kind of feedback is referred to as hereinafter as *critiquing*. The goal of this step is to investigate which strategy is favorable in the case of a mobile product recommender system. Therefore, the designed alternatives in *Table 3* incorporate the different feedback strategies and depict how they have been handled in this work.

Table 3: 'Giving feedback' alternatives.

	Strategy	**Description of Strategy**
Rating Stars	Rating	Item/features get a rating between 1 (horrible) and 5 (excellent) stars.
Like/ Dislike	Rating	Item/features get a 'like' or 'dislike'. Users can 'like' an item and still 'dislike' a feature of it.
Positive/ Negative	Rating, Preference	If the item is rated positive/negative, features can also only be rated same.
Critiquing	Directional or Replacement Critiques	Directional: Attribute is in- or decreased (e.g. price); Replacement: Attribute is replaced with another value (e.g. color).
System Alternatives	No explicit feedback	The system shows alternative items, differing in one or several feature values.

3.2.4 Considering Context

Another main goal of this work is to examine whether context-changes such as location, timestamp, budget, weather, companion and so on can influence the user's opinion about a certain interaction and change her favorite way.

3.3 Prototypes

Interaction design involves designing interactive products. Before deploying a final version, these products have to be reviewed, graded and maybe improved, which can be achieved through prototyping.

3.3.1 Low-Fidelity Prototype

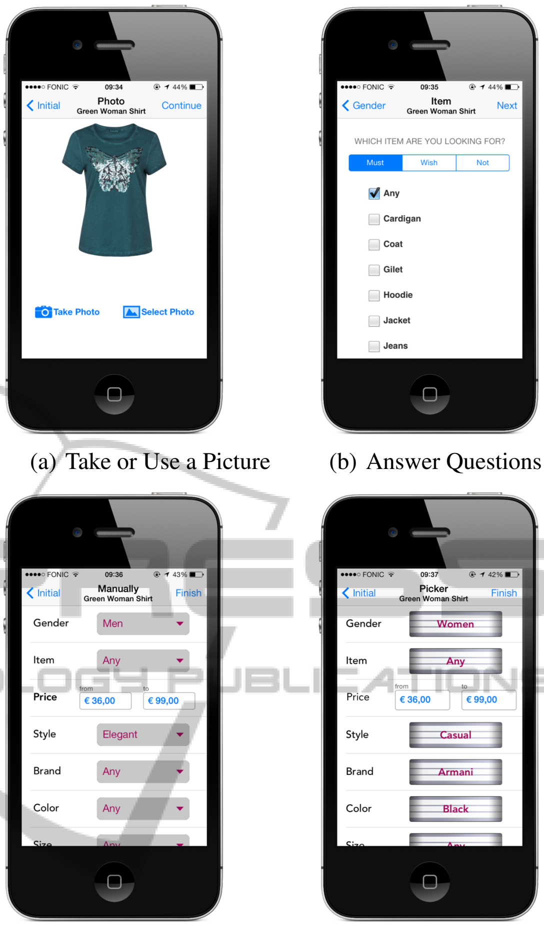
At this level of prototyping, the focus is on the product concept and general implementation, not on details. Low-fidelity prototypes developed in this work are hand-sketched and mainly have the purpose to eliminate the least attractive design alternative in each interaction step with an online survey which will be described in *section 4.1*. We implemented each of the selected prototypes from the survey as a higher-fidelity prototype to investigate it in the final evaluation test. This way the design idea was distinguished from implementation issues that could have arise.

3.3.2 Higher-Fidelity Prototype

After designing the low-fidelity prototypes and their evaluation, a clear idea of the basic design and a fairly comprehensive list of features should be available for the development process of higher-fidelity prototypes. The prototypes are implemented as an iPhone 4S application that does not have a running recommender algorithm in the background, nor an image recognition process. The complete interaction takes place with mocked data. We use eleven features to describe a clothing item: *Gender, Item, Price, Style, Brand, Color, Size, Fabric, Pattern, Sleeve Type* and *Length*. The *Item* value changes when alternating the gender value.

Setting Preferences. Four designs are implemented as higher-fidelity prototypes for the step of stating initial preferences: *Take or Use Image, Answer Questions, Manually Combobox* and *Manually Picker* (see figure 2). In the form of higher-fidelity prototypes, the alternatives *Take Picture* and *Upload a Picture* are merged and act as one acquisition strategy. That way, the user can either take a "live" image or upload an existing picture from one of the mobile phone's photo albums. The process continues with the system recognizing features from the picture and presenting them to the user in an overview list. The user can either change features that got a wrong value in the image recognition, give a value to features that were not recognized or finish the elicitation process. The *Answer Questions* strategy consists of twelve separate screens: one for each product feature and the last one as a static overview of stated values. The remaining two designs, *Manually - Combobox* and *Manually - Picker* are founded on the same layout idea, but differ in the domain visibility. When selecting a feature cell in the Combobox prototype, a new screen containing *all* feature values appears. By picking a value, the screen automatically disappears and the cell's combobox gets the chosen value. Within the Picker screen, a swipe action on the picker view, right-to-left, reveals a new value and hides the previous by pushing it to the invisible left. Thus the whole interaction takes place within a single window.

Presentation. Concerning the presentation of recommended items, the design alternatives *Single Item, List* and *Grid* are given the form of a higher-fidelity prototype (see *figure 3 a-c*). Each of the presentation views contains a *shop*-button, which conducts the user to the shop's web page containing a more detailed description and multiple images of the item from various perspectives.



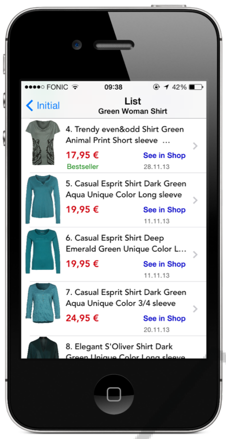
(a) Take or Use a Picture (b) Answer Questions

(c) Manually-Combobox (d) Manually-Picker

Figure 2: 'Setting preferences' interaction steps.

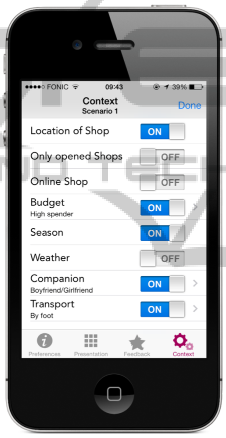
Giving Feedback. The designs *Rating Stars, Like/Dislike, Positive/Negative* and *Replacement* are developed as higher-fidelity prototypes to represent the different feedback strategies. Examples for the presentation views can be seen in *figure 4*. *Rating Stars* allows submitting a grading from 1 to 5 to the item overall, but also to its single feature values. *Like/Dislike* is identical to *Rating Stars* concerning its logic, with the only difference in the rating method which here is binary. In the *Positive/Negative* screen, the user selects either a plus for rating the item positively or minus otherwise. In the *Replacement* design, the user can replace each attribute with another explicit value (e.g. changing the brand of the item).

(a) Single Item



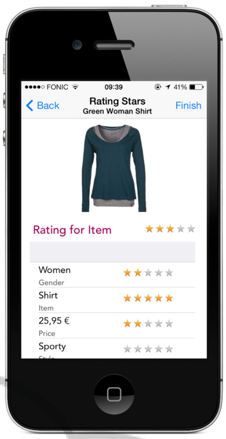
(b) List

(c) Grid



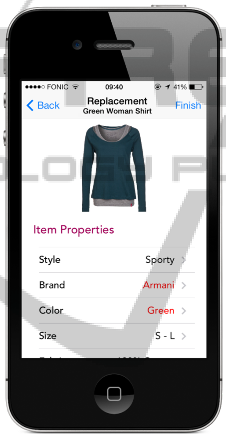
(d) Context Selection

Figure 3: 'Presentation of items' and 'context selection' interfaces.

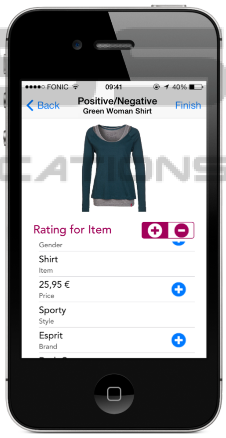


(a) Rating stars

(b) Like/Dislike



(c) Replacement



(d) Positive/Negative

Figure 4: 'Giving feedback' interaction steps.

Context. The context screen shows different context information (such as *Location of Shops, Currently Opened Shops, Availability of Online Shop, Budget, Season, Weather, Companion* and *Transport*) that can be included in the recommendation process when selected from the user. The idea behind the Context screen lies in *figure 3 d*, with the user explicitly stating the important context information, which should be included in the recommendation process in a certain situation. Our contextual testing approach is derived from (Baltrunas et al., 2012) and aims at finding out whether users prefer different methods of interaction depending on the current contextual situation. In our prototype, the user sets the values for the contextual factors *Budget, Companion* and *Transport*, the remaining factors are obtained by the system. The weather is measured by environmental sensors such as barometers and GPS sensors determine the user's current location. Within our user study we want to find out if particularly the user's budget, means of transport and available time influence the preferred interaction technique. In a real recommender system this context information could then be implicitly obtained by motion sensors that measure acceleration- and rotational forces along three axes (this is already embedded in recent iPhone and Android devices) and by accessing the user's mobile calendar and online banking account. However, trust and privacy aspects have always be taken into account.

4 Evaluation

Evaluating what has been built is very much at the heart of the interaction design. Its focus lies on ensuring that the product is appropriate, usually seeking to involve users throughout the design process. We first carry out an online survey to narrow down the design alternatives and reduce subject fatigue in the following user study. The main two goals of the evaluation are:

1. To find out which interaction and interface possibilities provide the best usability and user experience in supporting the interaction model steps (see *section 2.1*)
2. To conclude whether contextual change implies changes on the users' preferences about their favorite interaction and interface options for a mobile recommender system.

Despite the fact that this paper evaluates only the interaction design, without providing a working recommender system in the background, its aim still targets the usability and user experience domain of mobile recommender systems. Consequently, methodologies examining both recommender systems and mobile systems will be depicted.

4.1 Online Survey

The survey had the simple task of asking people what their preferences are regarding interfaces and which interaction functionalities they would value as important in a mobile shopping recommender system. The survey's goal was to collect fast user opinion on the developed paper prototypes (see *subsection 3.3.1*). The survey questionnaire disposed a total of 38 questions, divided into four blocks. Besides demographic questions, users were asked about preferences for eliciting item preferences, presenting recommended items and critiquing/giving feedback on an item. In total 46 people participated, 27 males and 19 females. The participants were 26.7 years old in average, ranging from 20 to 57. Based on the results of the online survey we included the most favorite interfaces and functionalities regarding a mobile shopping recommender system in the higher-fidelity prototype. Its evaluation will be described in the following.

4.2 User Study

Based on the results of the online survey, the developed higher-fidelity prototype described in 3.3.2 was judged within a user study with respect to the usability and user experience. A one-on-one usability study can quickly provide a great amount of information on how a product will be used.

4.2.1 Study Design

The study consisted of collecting data from three categories. First, the study data was logged by the higher-fidelity application during its execution. Thus, one is able to collect interaction data (e.g. the time users needed to finish the given task with an interface or the currently set preferences) in order to analyze and understand the user behavior (Rogers et al., 2011). Second, during the entire time of the user study, the examiner took notes on the users' comments (*Think Aloud method*). Third, a usability questionnaire collected general data about the person and the imprinting on the interfaces. During this study, the user was set up with three distinct tasks, one for each step in the product recommender interaction model. The application was made to act as a mobile clothing shop, a commonly known domain. Each developed design ran twice: first for a *green women's T-shirt* and afterwards for *beige men's trousers*. The questionnaires examined the differences in the subjective satisfaction with the user-friendliness of the designs. Another questionnaire collected demographic data and the level of shopping experience of individual trial participants. As the underlying base for the development of the questionnaire, the framework *ResQue* was used. ResQue consists of 13 constructs and a total of 60 questions, divided into four main dimensions (Pu et al., 2011a). The following perceived qualities of recommender systems were conducted within our questionnaire: *Ease of Use*, *Interaction Adequacy*, *Interface Adequacy*, *Control*, *Attitude/Overall Satisfaction*. With all questions not being suited for each developed design, the setup was slightly different for distinct interaction activities. Participants stated their opinion with a 7-Likert scale; from *(3) strongly agree* to *(-3) strongly disagree* with *(0)* being *neutral*.

The developed designs were evaluated in a lab-based study, which lasted for about an hour. As a recommender system has a wide audience, no specific user group was targeted. Each of the total eleven interfaces that were examined had an accompanying video on the interaction possibilities, shown before the start of every interface design. After the task completion for both items, users were asked to fill out a questionnaire about the design's usability in relation to ease of use, interaction and overall satisfaction. It should be mentioned that we encouraged participants to evaluate the pure interaction technique and to neglect the visual design used in this study. When all tasks associated with one interaction step were performed, the user was asked to choose her favorite and least favorite interface design from that group. The order in which the interfaces were presented to the subjects was randomly allocated, however staying within the interaction step. By changing the order, learning effects were avoided and each interface could be objectively evaluated.

The first group of interfaces served the user to explicitly describe the item having in mind to the system with a feature-value list consisting of eleven semantic features. The second interface group included interfaces presenting an initial set of recommended items. A set of 30 items for each initial item was mocked, acting as the recommended items. The set was sorted by the items' prices because participants expressed this feature as being the most important one in the previously conducted online survey. The user's task was to lookup for the item most likely similar to the item described in step one. For the final interaction step, a random item was shown to the user that had to be compared to the one looking for by rating preferences or replacing attribute values.

In order to examine context influence on the process of decision-making, the participant was asked to imagine herself in two certain context situations, as in (Baltrunas et al., 2012), and to determine which context factors are of high importance to her in that specific case and activate those factors within the context screen. The participant was asked once more to choose her favorite designs from each interaction step, but now according to the imagined context.

4.2.2 Results

The random sample included 21 evaluators, aged between 19 and 39 years with an average age of 26.5 years. We focused on average app users, however it should be noted that people with visual impairment or elderly might have evaluated the interfaces differently. The gender distribution was rather balanced with 52.4% of users being male and 47.6% being female. The means of the measured values, as well as the standard deviation σ of the examined interfaces are shown in the corresponding tables.

Setting Preferences. The first task included describing an item to the system. *Figure 2* shows the corresponding interface designs. By tracking the time from the beginning that occurs with the *green shirt* item to the end of describing the *beige trousers* item, the task could have been completed in around 2 minutes for the three interfaces *Take Or Use Picture*, *Combobox* and *Picker*, while *Answer Questions* needed almost 6 minutes (see *table 4* for exact values).

When asked about the ease of interaction to describe an item to the system (on a 7-Likert scale, 3 the best, -3 the worst rating), the participants' average rating was very similar among the three systems *Answer Questions, Combobox* and *Take or Use Picture*. Participants expressed much less satisfaction for the *Picker* alternative. Concluding from the participants' comments besides being complicated to interact with, *Picker* provided no visibility of the application domain what was perceived as bothersome.

Table 4: A comparison of the user study's results concerning the preference elicitation strategies.

	Questions	Combobox	Picker	Take/Use Image
Time	5.9min σ=2.58	2min σ=1.07	2.5min σ=0.82	1.9min σ=0.73
Ease of Use	2.1 σ=1.12	2.57 σ=0.73	0.38 σ=1.76	2.29 σ=0.76
Adequacy	1.43 σ=1.29	2.24 σ=1.02	-0.10 σ=1.92	2.10 σ=0.75
Control	1.52 σ=1.33	2.38 σ=0.79	1.19 σ=1.18	2.10 σ=1.07
Error-Free	1.57 σ=1.53	2.29 σ=1.03	0.67 σ=1.81	1.43 σ=1.14
Satisfaction	1.48 σ=0.14	2.33 σ=0.94	-0.05 σ=1.76	2.10 σ=0.81

When asked whether the design presents an adequate way to express preferences, almost all ratings for *Answer Questions, Combobox* and *Take or Use Image* were above zero. Picker was the only alternative rated negative on average. These results are almost mapped to the issue of whether the design offers an adequate way to summarize preferences. In this context, some participants stated that they wished a dynamic overview design, i.e. to be able to jump to a certain question when a preference is selected in the overview.

Looking at the rating distributions on the level of control participants perceived when telling the system what an item they want, as well as whether they can paint a longtime interface-usage without errors, no interface has fallen into negative space of ratings. *Combobox* provided the highest feeling of control, *Picker* the lowest.

When asked what the overall impression of the system was, participants expressed high sympathies for *Combobox* and *Take or Use Picture*, while *Picker* was rated worst (due to the concerns already mentioned above).

Result 1: *'Combobox' is in our study the favorite preference elicitation strategy and 'Picker' the worst concerning ease of use, adequacy, control, accuracy and satisfaction. 'Take/Use Picture' is in our evaluation always second place and 'Answer Questions' third, with the exception of the accuracy category. It is worth mentioning that 'Answer Questions' needed almost the triple of time compared to the other preference elicitation strategies.*

Table 5: A comparison of the user study's results concerning the different presentation interfaces.

	Grid	List	Single Item
Time	1.1min σ=0.89	1.3min σ=0.59	1.5min σ=0.65
Ease of Use	1.95 σ=1.50	2.42 σ=1.09	1.6 σ=1.74
Adequacy	1.33 σ=1.61	2.05 σ=0.90	0.9 σ=1.89
Sufficient Information	0.71 σ=1.72	1.86 σ=1.32	1.6 σ=1.2
Scroll-Downs	10.89 σ=5.63	15.61 σ=12.65	- -
Satisfaction	1.24 σ=1.6	1.76 σ=0.92	0.15 σ=2.03

Presentation. We evaluated three different presentational interface designs (see *figure 3*). By looking at the average time of choosing the best suited item for each design alternative, there is only a subtle difference with participants completing their session (around 1.3 minutes). *Table 5* shows exact time values.

When asked if it was easy to use the interface, *List* performed best on average, followed by *Grid* (second place) and *Single Item*. This rank order also reflects the overall satisfaction perceived measurement. Here, the span of ratings for *Single Item* was larger than in *List* and *Grid*, including high positives, but also high negatives and reaches last place.

Things change when looking which design alternative has the most adequate interface as well as if the interface provides sufficient information. As expected, *Grid* drops down to last place when asked if it provides sufficient information and is second when asked about the layout's adequacy. *List* is rated best in both categories, while *Single Item* is considered as least adequate but second concerning the information content.

As already expected, participants scrolled more often in order to find and select the most appropriate item when using the *List* interface compared to the *Grid* interface.

Result 2: *In this study, users favored the presentation of items in a 'List' view, while the 'Grid' view was ranked second and the 'Single Item' view worst in relation to ease of use, adequacy and satisfaction. However, 'Grid' is regarded as not giving sufficient information compared to the other two designs.*

Giving Feedback. We implemented four different feedback strategies within our higher-fidelity prototype (see *figure 4*). Regarding the time measurement, the *Positive/Negative* way of feedback scored best followed by *Replacement, Like/ Dislike* and *Rating Stars* (which is the most time consuming feedback strategy). However, the difference is almost imperceptible (see *table 6* for exact values of the time measurement).

Table 6: A comparison of the user study's results concerning the feedback method.

	Like/ Dislike	Positive/ Negative	Rating Stars	Replacement
Time	1.3min σ=0.54	1.2min σ=0.73	1.4min σ=0.56	1.3min σ=0.35
Ease of Use	1.71 σ=1.55	1.67 σ=1.64	2.19 σ=1.1	2.38 σ=0.79
Adequacy	0.38 σ=1.94	0 σ=2.14	1.14 σ=1.52	2.05 σ=1.25
Satisfaction	0.48 σ=1.47	0 σ=1.66	1.33 σ=1.49	2 σ=0.87

Participants were asked to evaluate the ease to use the interface. The *Positive/Negative* design needed extra explanations for its logic after showing the introduction video. This reflects in the ratings participants have given (see *table 6*). Participants complained mostly on the restriction to positive- or negative-only ratings, while the main point of criticism of the *Like/Dislike* interface was its lack of a default, neutral rating option.

Continuing, participants were asked to consider the interaction adequacy of revising preferences with each feedback strategy. The *Replacement* design achieved first place, *Positive/Negative* was elected worst. In between are *Like/Dislike* and *Rating Stars*. The overall satisfaction maps the interaction adequacy almost one-to-one.

Result 3: *Regarding the ratings for ease of use, adequacy and satisfaction, the 'Replacement' critiquing strategy is ranked best in our user study, followed by 'Rating Stars', 'Like/Dislike' and 'Positive/Negative', being the least favorite strategy. However, 'Positive/Negative' is the most efficient critiquing approach in terms of time.*

Context. The participants were also asked to imagine themselves in two distinct context situations, denote the important contextual factors and pick a favorite from the evaluated variants, but now according to the situations. This context evaluation approach already produced good results in (Baltrunas et al., 2012). The two scenarios were described as follows:

Scenario #1: *You have an important meeting in 30 minutes, but you just spilled coffee all over your shirt. You are in panic looking to buy a new one. You don't care about money; you just need a new white shirt, fast. While walking around the neighborhood to find a shop, you are using the recommender app to find you a perfect match nearby.*

Scenario #2: *You are at home, surfing the space of internet to buy your mom a present for Christmas which is in two weeks. You are looking for a nice white woolen sweater, winter-appropriate. Your budget is unfortunately very limited.*

While under pressure and having a reference product, almost all participants would either *Take an Image* of an item or describe it with the *Combobox* design. However, without the pressure factor and with the lack of a reference product (context 2), the number of favorite votes for the *Take or Use Image* design drops down to zero. On the other hand, Combobox increases its advantage, with the *Answer Questions design* following. This means that, when asked about favorites according to context, 81% parted with a 48:33 ratio between participants that changed their favorite vote for one context scenario and for both.

Looking at the item's presentation, the ratio in favor of *List* and *Grid* changes. For the first situation, *Grid* has slightly more votes (11 vs. 8), while in the second situation; *List* has 10 votes and 3 more than *Grid*. In the terms of change, 19% of participants did not change anything, 43% changed at least one, while 38% changed both of their favorites.

Not much changed regarding the overall rating of the favorite feedback strategy. *Replacement* is the participants' favorite revision option. However, only a quarter of participants stood up to their previously rated favorite design: 48% changed in both context scenarios, and 29% in one of them.

Result 4: *Only when under pressure, 'Take or Use a Picture' is a very popular preference elicitation strategy among smartphone users according to the results of our user study. Also the participants' favorite presentation interface as well as favorite method to provide feedback depends on the context situations.*

5 CONCLUSIONS AND FUTURE WORK

This work described an accomplished interaction design process regarding mobile product recommender systems using critiquing to elicit the user's preferences. We focused on items whose appearance plays an important role instead of technical features and therefore selected a mobile clothing recommender system as application scenario. The process resulted in developing eleven interaction design alternatives on an iPhone, categorized into three interaction activities: the initial preference elicitation process, the presentation of the resulting recommendations set and the preference feedback process. As a result of an executed user study evaluating the implemented interactive designs, we could inter alia show that the *Combobox* preference elicitation strategy, the *List* view, as well as the *Replacement* feedback strategy are the most preferred design alternatives of a mobile product recommender system concerning ease of use, adequacy and overall satisfaction. The study also showed that contextual change heavily influences the participants' choice of favorites. Iti developers of mobile product recommender systems should automatically obtain the context situation and adapt the interfaces accordingly. We have to note that the most suitable interaction technique often depends on the recommendation algorithm, type of users, data, context, device and recommendation task. However, the results should be taken into account by developers of mobile shopping recommender systems using critiquing as primary feedback strategy. We assume that the resulting interaction techniques can be applied to all mobile scenarios where the item's appearance matters. We therefore already started working on a mobile recipe and restaurant recommender system to find out if our results can be generalized. We will also evaluate the most preferred designs in combination, since in a real system, a user will interact with only one sequence of the three identified interaction steps. Future development also includes the integration of a recommendation algorithm with a large dataset evaluating the final design, also with a larger number of evaluators and different display sizes. Beyond explicit, interesting will be to examine how an implicit form of feedback would perform in terms of usability and user experience.

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