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Rating Methods for Proactive Recommendation on Smartwatches

Janosch Maier, Wolfgang Wörndl

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Janosch Maier

Wolfgang Wörndl

Technische Universität München
Department of Informatics
Boltzmannstr. 3
D-85748 Garching
{maierj, woerndl}@in.tum.de

ABSTRACT

This paper analyzes possible interaction methods for using a recommender system on a smartwatch. As prerequisite, we describe interaction patterns currently used by Android Wear applications. Based on a prototype implementation the interaction methods action buttons, two button card and swipes are compared against each other.

In a user study, 31 participating students were asked to rate restaurant recommendations offered in the setting of a context-aware, proactive recommender system. For each of the interaction methods, they saw the same three recommendations. Afterwards, the participants judged the user experience of the methods. The reaction time was measured for each recommendation.

The study showed, that the two button card and the swipes methods outperform the action buttons method with regard to reaction time and user experience. The two button card was ranked highest in terms of use quality, the swipes method in terms of design quality. About half of the participants liked each of these two methods best.

These findings are especially interesting, as the action buttons method is the interaction pattern included in most Android Wear applications, because it is easier to implement as the other methods.

Keywords

Smartwatch, Wearables, User Interaction, Recommender, HCI, Android

1. INTRODUCTION

Apple, Asus, LG, Motorola and Samsung, the big players in the mobile device market have smartwatches in their product portfolio now [10, 12, 8]. With Android Wear, Google has made development for smartwatches easy. The integration into the Android system enables developers to easily add functionality for smartwatches into their applications [13]. For this research a Moto 360 smartwatch from Motorola was used. Therefore the descriptions of interaction methods refer to what is currently possible on an Android Wear device.

Typical use-cases for smartwatches are notifications especially for organizational functionalities and messenger services [29]. A user might see his next appointment synced from his electronical calender without the need to pick up his phone (See figure 1). When a call is received, the user could see who is calling directly from his wrist.

Figure 1: A calendar overview on the Moto 360 smartwatch

To allow interaction, the smartwatch handles touches on the screen, voice input [11] or gestures [15, 3]. However, smartwatches can be seen as low-interaction devices. A typical interaction on an Android device shall not be longer than five seconds [14].

Android Wear integrates context-aware notifications. A context-aware recommender system could make use of this notification design. A system might recommend places to visit based on the location of the user and the time of the day. For example around lunch time a user can get a recommendation of restaurants nearby. In a proactive recommender, these recommendations can be pushed to the user, without explicit user interaction [27]. Recommender systems [25] rely on user feedback to create useful recommendations. Therefore, valuable feedback for the recommender system would be, whether the recommendation is is fitting at this moment. This feedback is then used to increase the fit of the next recommendation.

This research describes different interaction types of how a user can provide feedback to the recommender system after s/he received a recommendation. As an action on the smartwatch requires less effort than using a smartphone, this might increase the users' willingness to rate recommendations. Even though the interaction takes only a few seconds, this goes beyond notifications. To get insight in the process of rating recommendations, we developed an interactive prototype. The prototype has different possibilities (two action buttons on different screens, two buttons on one screen, swipes) to rate the recommendation either as positive or negative. A study utilizes the prototype to analyze which interaction types are more comfortable for users.

The following section 2 briefly describes recommender systems and the data needed for their use. Chapter 3 describes the state of the art for smartwatch usage and highlights possible use cases for smartwatch recommenders. In chapter 4 the theoretical basis for interaction on Android Wear devices is presented. Chapter 5 looks at the prototype developed for the study described in section 6. Section 7 explains the findings of the study. The last section 8 discusses the results and suggests future work.

2. RECOMMENDER SYSTEMS

Recommender systems [25] rely on ratings [1] to give meaningful recommendations to users. Based on the rating of several items by one user, items with similar features can be recommended to the same user (content-based recommendations). Based on the similarity of ratings from different users, an item can be recommended to other users (collaborative recommendations). Therefore ratings are important for a functioning recommendation system. Additionally other information such as the current location [22] can be useful for recommendations. In contrast to data that is measured (e.g. location), the user has to act himself to rate reccomendations. Therefore an unintrusive way for gathering ratings may improve the quality of recommender systems. As a good system design will increase the system satisfaction [28, 4] of a recommender system, different interaction methods for ratings using smart watches were developed and are compared with regard to user experience in the next chapters.

In proactive recommender systems, the user does not request a recommendation. Recommendations are pushed to the user, when the context is suitable [27]. For a restaurant recommendation system, this is the case when it is lunchtime and fitting restaurants are nearby. For such recommender systems, smartwatches can provide a benefit, as the notifications are less intrusive for the users as on smartphones [5]. This might lead to higher acceptance. Especially in social situations, where it might be uncomfortable to check a notification on a smartphone, the smartwatch could provide a suitable platform. Data stored on a smartphone (e.g. calendar entries) im combination with smartwatch gathered data (e.g. walking speed) might provide a better context data for recommender systems. Taking recommenders onto the smartwatch is a prerequisite to get access to such data.

Even though the setting of a recommender system is the background for the study, no real recommender system is controlling the developed prototype. Therefore a systematic description how a recommender system might generate lunch recommendations based on location, time, user preferences and rating is omitted here. For more information on evaluating the context to chose suitable notifications, please refer to [9].

3. RELATED WORK

Though smartwatches are available, the mass of users have not yet adopted them by now. Current research focuses mainly on the use cases of smartwatches and their design features.

Kent Lyons surveyed 50 participants in an online study that wore digital watches to get insight in how to design a smartwatch [24]. The data suggest, that the clock faces – called watchfaces in this context – should show time and date. Applications such as timers might be beneficial for a large user base e.g. while doing exercice or cooking. However there are many different types of digital watch users, which suggests, that many different types of smartwatches are needed to match the users' needs.

Cecchinato, Bird & Cox interviewed ten early adopters of smartwatches. The participants used their smartwatches "for notifications, as an augmented traditional watch, as a health tracker, as an entertainment device or a combination of the above" [5]. Smartwatches are less intrusive than interaction with the phone, especially in social situations. However the early adopters lack to see real real benefits. Similar to [24] the participants suggest, that a variety of watches is needed to match everybody's desires.

Bernaerts et al. created an augmented office environment with smartwatches [3]. The smartwatch could serve as authentication device instead of a key card. Knocking gestures can be detected by the smartwatch and send to the owner of a specific office, when s/he is not available. However there is still some research needed in order to correctly identify a door without the need of using the smartphone.

Chen et al. explored joint interactions on a smartphone and a smartwatch [6]. The smartwatch can be used for choosing tools or to detect the wrist orientation while interacting on the smartphone or for using cross-device gestures. The interaction methods are rated differently, depending on the use case. The users liked the interaction with the smartwatch in cases, where it provided high benefits compared with a traditional use with only the smartphone.

The 58 participants of a study by Gallego, Woerndl & Huecas showed that the usefulness of a restaurant recommender system differs whether the user is in a hurry, or not [9]. Smartwatches containing pedometers can provide data helping to evaluate the user's context. In addition the study showed, that users liked a widget based approach better than a notification based approacd for getting recommendations. Widgets are less intrusive than smartphone notifications, but it is easier to miss a message on a widget. Smartwatch notifications are also less intrusive than smartphone notifications, however they notify the user, so that s/he is less likely to miss information compared to only having a notifying widget. Therefore smartwatches might be a good medium in such a use case. However this was not tested within this study.

47 seniors from Greece and Germany participated in a study gathering requirements for an ambient assisted living system [18]. This system should serve as a recommender assisting in life-style and addressing medical needs. In both countries the seniors liked the idea of using a smartwatch for such a system more than other devices. The Germans were concerned of notifications in unpleasant moments. The

Greeks feared missing important information of the system. In both cases, the smartwatch might outperform interactive displays, robots and smartphones, as it is unintrusive but nevertheless always at hand.

These use cases already show, that smartwatch usage exceeds notifications. Therefore interaction methods are important to provide a good usability. Current interaction methods now follow in the next chapter.

4. ANDROID WEAR INTERACTION

The Android Wear design guidelines describe several forms of interaction [17]. In addition there are further interaction methods that are imaginable or already implemented by certain applications.

In general, all on screen output is ordered into cards. By swiping on the device screen, the user can change the screen content. Swiping up and down replaces the current screen with a new card. For example, the user can change to the weather card from the currently shown calendar. Swiping horizontally shows more information on the current topic. For example, on the weather card, a swipe from right to left might produce a forecast, while the first card shows only the weather for the current day. A swipe from left to right goes back to the card content before. If the leftmost card is swiped again, the notification will close.

4.1 On Card Action

If the user is expected to only invoke one action while looking at a certain notification, s/he can click on an on card action. A small button is included into the notification that the user sees. For example while looking at a music card (figure 2), the music can be paused or played.

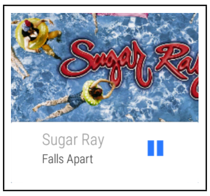

Figure 2: The on card action pauses the song

4.2 Action Button

Android notifications for smartwatches are extendable with action buttons. A swipe from right to left then displays the action button screen. The action button fills one full screen and enables the user to perform one specific action by touching the button. Several buttons may be attached to and reachable by swiping multiple times. Figure 3 shows an action button to start a navigation on the smartphone.

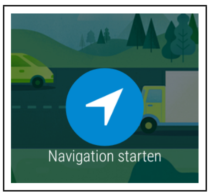

Figure 3: The action button to start a navigation

4.3 Multi Button Interface

More actions can also be grouped on one screen. For example the music card offers four actions to the user (figure 4). S/he can increase or decrease the volume with the top and bottom button. With the left and right buttons s/he can play the previous or the next song.

Figure 4: Music controller with multiple buttons

4.4 Swipes

Swiping to the left or the right is used in some applications to represent confirmative and dismissive actions, respectively. This does not integrate well in the common Android Wear notification stream, as swiping cannot be used anymore to change between cards. The phone notification uses this pattern. This is shown in figure 5. A swipe from right to left means accepting the call whereas a swipe from left to right declines the call. So the swipe direction that usually shows more information is the accepting swipe. The swipe that usually goes back or dismisses a card is the declining action. In the phone application further buttons appear, if the user swipes from bottom to top to show automated answers that can be sent to the caller. The application Tinder (figure 6) also uses this swipe method to show admiration or dislike for one picture.

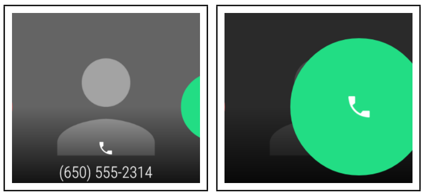

Figure 5: Swipe interaction in the phone application

Figure 6: Swipe interaction in the tinder application

4.5 Free Form Gestures

Free form gesture means, that a gesture is not drawn on a screen, but freely in the air. With a smartwatch, this can be a turn of the wrist, as currently promoted for Android Wear devices [16]. This is not yet fully available for third party applications. However there are already applications that make use of free form gestures on wear devices [20, 30]. Research on free form gestures in business use is ongoing [3].

4.6 Voice Input

Actions that rely on textual information such as sending messages with a custom text cannot be implemented easily on a small size screen [7]. Current developer guidelines propose to use voice input instead [11, 17].

4.7 Comparison of interaction methods

Due to the multitude of different interaction methods, this work tries to address possible differences between these forms. Reaction time and perceived user experience are interesting variables to test. The reaction time is a measure, how easy some action can be achieved. The user experience directly influences, how the user likes a product and is therefore an important research factor. The following questions shall be answered.

Q_1 : Does the interaction method affect the reaction time?

Q_2 : Does the interaction method influence the perceived user experience?

The following study only takes the interaction methods "action buttons", "two buttons" and "swipe" into account, as an on card button can only invoke one action. Free form gestures are not yet available to be used by applications. However voting while turning your wrist to show a thumb up or down might be interesting to evaluate in the future. Voice control may not be suitable for such a brief action. Therefore, these methods are not further examined, but only shortly mentioned during the study.

5. IMPLEMENTATION

The implemented prototype consists of a smartphone (smartphone) application (see figure 7) which guides the researcher through the study and a smartwatch application with which the participant interacts. The smartwatch application is created explicitly for the Motorola Moto 360, as this device was available for the researcher. Due to the German participants in the study, the text on the screenshots appears in German. The application is called *lunch checker* to create the image of a recommender system which recommeds places to eat lunch.[1]

5.1 Smartphone Application

This application serves as an interactive prototype. There is no recommender system running, that shows any of these notifications based on real recommendations. The researcher creates a new participant. The smartphone then assigns the participant randomly to one of six groups and shows the participant number to the researcher. Based on the group, the three interaction methods are permutated to avoid bias. When the researcher clicks forward, a button appears where s/he can send a notification to the smartwatch. This button is clicked three times, to show three different locations to the participant. Each click in the smartphone application produces the Android Wear device to show a notification that recommends the user a place to eat. Then the researcher clicks forward and gets the same screen for the second interaction method. Here s/he creates three more notifications. Another forward click sends him to the third interaction method. There the researcher sends another three notification and then concludes the experiment for this one participant.

[1]The code for the application is available on: `https://github.com/Phylu/smartwatch_interaction`

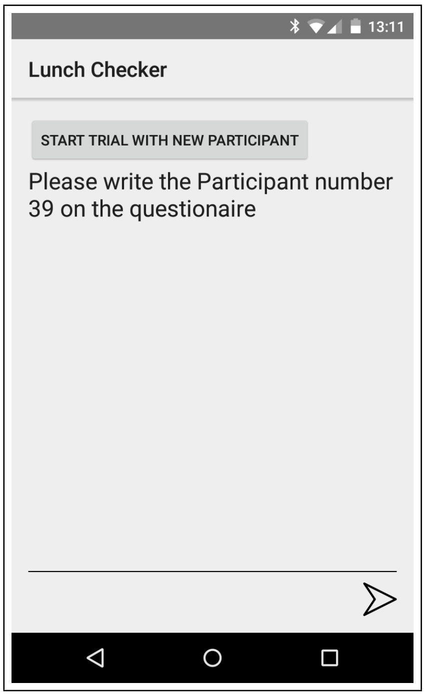

Figure 7: Smartphone application to control the wear notifications

For each of the interaction types, three notifications with different recommended locations exist. The recommended restaurants are located around a university building in Munich.

The researcher clicks the button on the phone to present a notification on the smartwatch. This starts a timer on the smartphone and use the Wearable Message API to create a message (listing 1). The API then sends the message containing the location and the interaction method to the smartwatch (listing 2).

```
%ActionButtonActivity.java
MessageThread t = new MessageThread(
↪ mGoogleApiClient, getResources().getString(R
↪ .string.action_button_notification),
↪ locations[getCounter()]);
participant.startCounter();
t.start();
```

Listing 1: A Button Click creates a message thread

```
%MessageThread.java
public void run() {
    Wearable.MessageApi.sendMessage(
    ↪ mGoogleApiClient, node.getId(), method,
    ↪ locationName.getBytes()).await();
}
```

Listing 2: MessageThread sends message to wear device

Then the smartphone application waits for a response of the smartwatch (listing 3). When a response is received, the timer is stopped and the reaction time is stored for this location. In the end, there are nine measurements for one participant: Three interaction methods with three locations each.

```
%ListenerService.java
public void onMessageReceived(MessageEvent
↪  messageEvent) {
    if(messageEvent.getPath().equals(getResources
    ↪  ().getString(R.string.
    ↪  action_button_notification))) {
        participant.addActionButton(Integer.
        ↪  valueOf(msg));
        sendIntent(ActionButtonActivity.class);
     }
     ...
    }
```

Listing 3: ListenerService is waiting for a response message

5.2 Smartwatch application

Similar to the smartphone application, the smartwatch application has a ListenerService, that waits for messages. As soon as a message from the smartphone application is received, the corresponding notification is started. The different methods, how a notification was presented are described below. When the user has voted on the recommendation, a message is send back to the phone.

These messaging services are needed, as current methods for sending notifications to the smartwatch do not allow to receive input with the two buttons or swipe methods. To make sure, that the measurements for the reaction time are comparable, the action buttons notifications were also send this way.

The first notifiaction implementation (figure 8) uses the standard options provided by Android to show notifications with interactive elements on smartwatches. This implementation is called action buttons (AB). The notification takes a picture of the location, the name of the location and shows them to the user as Android Wear cards. If the user swipes from right to left on the card, an action button appears to vote the recommendation up. Another swipe in the same direction shows another action button to vote the recommendation down.

Figure 8: Action Buttons Notification

The second notification implementation (figure 9) uses a custom card design which allows the user to vote directly on the main notification card. This interaction method is called two button card (TB). The background of the notification also shows the picture of the location as for the first method. In addition there are two vote buttons. The button on the right side of the screen will vote the recommendation up. The left side button will vote the recommendation down.

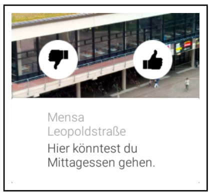

Figure 9: Notification with Two Button Card

The third notifiaction implementation (figure 10) uses swipes [26, 2] to determine the voting. This implementation is called swipes (SW). The notification card looks similar to the action button implementation. Two colored circles move in and out on the sides of the screen to show the voting directions. When swiped from right to left, the green circle grows and the recommendation is voted up. On a swipe from left to right, the red circle becomes bigger and the recommendation is voted down.

Figure 10: Swipes Notification

6. USER STUDY

In the conducted user study, an experimenter described the situation of a lunch recommending system to the participants. They then got notifications on a smartwatch. The participants answered questions concerning the notifications.

6.1 Sampling

For this study, we asked 31 students (14 male, 17 female) aged $M = 23.065$ ($SD = 2.999$) from Munich universities to participate. The participants studied mainly 'pedagogy' (14), 'computer science' (2), 'information systems' (2), 'mechanical engineering' (2), 'prevention, inclusion and rehabilitation for people with hearing impairment' (2) and 'psychology' (2). Seven participants studied a different subject.

6.2 Design

The experiment consisted of a within subject design. Each participant saw all different forms of the manipulated variable. To prevent sequence effects, the order of the manipulations was permutated. There are six different groups to create all sequences for one independent variable with three values. Each participant was randomly assigned to one of these groups before the experiment as shown in table 1. The abbreviations are described in in chapter 5.2.

6.3 Manipulated Variables

The independent variable is the interaction method of the notification. The variable has the three manifestations AB,

Group	Number of participants
AB-TB-SW	5
AB-SW-TB	5
SW-AB-TB	5
SW-TB-AB	5
TB-AB-SW	4
TB-SW-AB	7

Table 1: Randomized allocation of participants

	Action Buttons	Two Buttons	Swipe
Attractiveness	.95	.94	.92
Stimulation	.86	.88	.84
Novelty	.61	.64	.64
Efficiency	.81	.71	.71
Perspicuity	.79	.63	.77
Dependability	.76	.78	.71

Table 2: Cronbachs Alpha for scales on the UEQ

TB and SW. The manifestations correspond to the previously described implementations in the smartwatch application. In each of the cases the specific form of interaction is shown to the user.

6.4 Process

In a single execution of the experiment, the experimenter described the testing situation to the participants: "You are trying a new recommender system, that will provide you with recommendations where to eat lunch. The application is called Lunch Checker." The experimenter handed a laptop to the participant to declare his consent of participate in the study. Then s/he handed a smartwatch to the participants and explained general usage of the smartwatch and several installed applications. The experimenter told, that now the participant will receive notifications on the watch. After receiving the notification, the participant voted the recommendation either up or down. According to the assigned group, the participants got the three series of recommendations (AB, TB & SW) in different order. Each series consisted of recommendations for three different locations as described in chapter 5.1. After each series, the participants filled out a questionaire on the user experience. In the end, the participant answered some follow up questions and provided demographic data in the questionaire.

6.5 Measured Variables

For statistical analysis the variables reaction time and user experience were measured for each interaction method. In addition, questions about further interaction methods were answered.

The time between the display of the notification and the received voting is collected to see whether the interaction method has influence on how long it takes the user to respond to the notification. A long interaction time might show, that an interaction method is comparably difficult to use. We refer to this time as reaction time.

The user experience was measured to compare how users perceive the interaction methods. A good user experience might show, that an interaction method is superior to others. To measure the user experience, we used the User Experience Questionaire (UEQ) method [21], which gives the following five scales for different aspects of user experience: Attractiveness, Stimulation, Novelty, Efficiency, Perspicuity, Dependability. The scales with their values for Cronbachs Alpha are shown in table 2. The scales Stimulation and Novelty are part of the greater factor Design Quality. The scales Efficency, Perspicuity and Dependability represent the Use Quality of the Software. On this questionaire, word pairs are used with a 7-point scale to rate them. Sample word pairs for the scale stimulation are: 'valuable – inferior' or 'boring – exiting'.

To get an impression about the interaction methods free form gesture and voice control, a questions ask the user whether s/he thinks that about certain interaction methods. The questions ask the user how s/he would like the interaction methods. The possible answers range from 'not good' to 'pretty good'.

One question asked the participants, which of the interaction methods they liked most. A follow up question with a free text field asked about the reasons for that.

6.6 Statistical Analysis

For the used t-test, the R package used assumes unequal variances [19], we therefore went without checking the variance of the different groups. For the variance analyses, looking at quantile-quantile plots suggest, that all dependent variables are normally distributed. A significant Mauchly's test shows that for the reaction time, sphericity is violated. In this case, the corrections provided by the R function ezANOVA [23] were used and the Greenhouse-Geisser p-values are presented in the result.

7. RESULTS

The following results show, what influence the tested interaction methods have and which methods users like best. Further methods are shortly evaluated.

7.1 Effect of interaction method on reaction time and user experience

The mean of the measured reaction time of all trials in milliseconds was $M = 4723.437$ ($SD = 1591.321$). For the AB method, the reaction time was $M = 5888.215$ ($SD = 1997.011$), for the TB method $M = 4014.634$ ($SD = 1006.993$), and for the SW method 4267.462 ($SD = 792.2841$). The reaction times are visualized in figure 11.

A one-factorial analysis of variances with repeated measures shows, that these differences are significant $F(2, 60) = 15.324, p = 0.000, \eta^2 = 0.275$ (Greenhouse-Geisser corrected p-value). Therefore, Q_1 is accepted.

A pairwise comparison using t-tests with adjustet p-values shows, that the AB method differs significantly from the TB method ($p = 0.000$) and the SW method ($p = 0.001$). The difference between the TB and SW method is not statistically significant ($p = 0.223$).

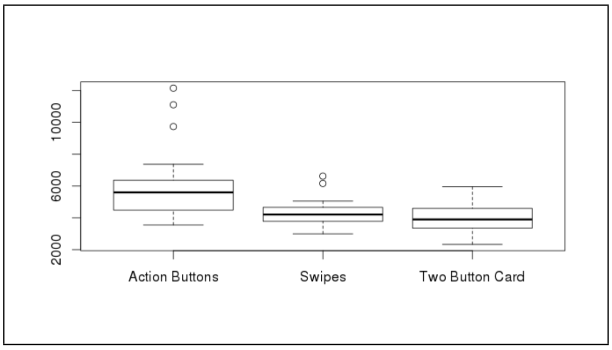

Figure 11: Reaction times by interaction method

The measured values of the UEQ for all interaction methods are depicted in table 4. Figure 12 visualizes the means for all scales. To test the differences in user experience based on the interaction method, we conducted six ANOVAs. For the different scales the ANOVAs give the following results:

Attractiveness	$F(2,60) = 3.188,$	$p = 0.048,$	$\eta^2 = 0.039$
Stimulation	$F(2,60) = 6.111,$	$p = 0.004,$	$\eta^2 = 0.075$
Novelty	$F(2,60) = 9.897,$	$p = 0.000,$	$\eta^2 = 0.164$
Efficiency	$F(2,60) = 8.856,$	$p = 0.000,$	$\eta^2 = 0.134$
Perspicuity	$F(2,60) = 10.857,$	$p = 0.000,$	$\eta^2 = 0.183$
Dependability	$F(2,60) = 6.512,$	$p = 0.003,$	$\eta^2 = 0.051$

The ANOVAs show significant effects in all cases. Therefore Q_2 is accepted.

Pairwise t-test show diferences between the various methods. Table 3 shows which methods produce significantly different values (denoted by *).

	AB/SW	AB/TB	TB/SW
Attractiveness	0.124	0.024 (*)	1.000
Stimulation	0.031 (*)	0.422	0.005 (*)
Novelty	0.009 (*)	0.125	0.001 (*)
Efficiency	0.014 (*)	0.001 (*)	0.325
Perspicuity	0.237	0.001 (*)	0.002 (*)
Dependability	0.173	0.003 (*)	0.083 (*)

Table 3: p-values showing differences in user experience depending on the interaction method

7.2 Further interaction methods

On a scale from “Not good” (1) to “Very Good” (5), the idea of using free form gestures was rated $M = 3.419$, $SD = 1.455$. Using voice commands was rated worse with a rating of $M = 2.871$, $SD = 1.204$. Due to the difference of the scales, a comparison with the presented interaction methods is not possible.

7.3 Best interaction method

The question which interaction method the participant liked most gives a diverse picture. 15 participants liked the TB method best, 13 the SW method and three the AB method. A question why they liked this method shows, that both groups (TB and SW) think this method is clearly arranged, fast and easy to use. One participant liking the TB method said “This method was most clearly arranged”[2]. A participant who liked the SW method stated, that “[t]his method was most clearly arranged, as the bounded work surface was not wasted on ‘unnecessary’ buttons.” The three people liking the action button method best, also think that this method is clearly arranged. One participant said “Clearly arranged, however not boring”.

8. CONCLUSION

The findings of the study show, that there exists a difference in the reaction time and the perception of different interaction methods on a smartwatch. The following chapers shall summarize these findings and highlight their relevance.

8.1 Discussion

The results show, that there are different perceptions of the interaction methods. In general, one could say, that the AB method is the worst option. It is less attractive, perspicuous and dependable than the TB method, less stimulating and novel as the SW method and less efficent than both TB and SW. In addition, only three out of the 31 participants rated it as the best interaction method. The reaction time of the AB method is significantly lower as the of both TB and SW (See figure 12). This is especially noticable, as this method is the standard method to attach interactive elements to Android notifications on Android Wear devices.

The design quality of the SW method is better than the TB method. However two of the three factors for use quality are significantly better rated for the TB method than for the SW method. There was no visible difference in the attractiveness of these forms. Therefore the TB method is seen as better to use by the users, while in contrast, they thought the SW method had a better design. A difference in the reaction time could not be found between these interaction methods. About half of the participants liked each of those methods best. Therefore no interaction method can be seen as best for this use case. A clearer differentiation between the TB and SW method is interesting in the future.

The reasons why participants rated one interaction method best are similar in each of the cases. This suggests, that it is important for most of the users, that a user interface is clearly arranged. However different users perceive differently what means clearly arranged for them.

The study showed, that the users liked the interaction methods who have a good use quality and design quality. Additionally these interaction methods have a significantly lower reaction time. Interaction with the smartwatch makes more fun, if the device looks good and the user knows what to expect, while interacting with the device. Smartwatch interaction is more than just looking at notifications.

8.2 Future work

Further testing, why the methods TB and SW are both seen as best by large parts of the users is interesting. A possible explanation might be, that for some users design is more important than use quality, whereas it is the other way round for others. Research, how this differs for use cases or devices might be interesting for the future. One participant

[2]All participant quotes are translated by the author

	AB	TB	SW	Total
Attractiveness	$M = 0.704, SD = 1.363$	$M = 1.247, SD = 1.313$	$M = 1.247, SD = 1.210$	$M = 1.066, SD = 1.308$
Stimulation	$M = 0.411, SD = 1.175$	$M = 0.218, SD = 1.335$	$M = 0.976, SD = 0.900$	$M = 0.535, SD = 1.183$
Novelty	$M = 0.645, SD = 1.004$	$M = 0.274, SD = 1.081$	$M = 1.306, SD = 0.843$	$M = 0.742, SD = 1.060$
Efficiency	$M = 0.976, SD = 1.351$	$M = 1.960, SD = 0.949$	$M = 1.734, SD = 0.908$	$M = 1.556, SD = 1.156$
Perspicuity	$M = 1.371, SD = 1.206$	$M = 2.476, SD = 0.663$	$M = 1.661, SD = 1.062$	$M = 1.836, SD = 1.098$
Dependability	$M = 1.411, SD = 1.062$	$M = 1.968, SD = 1.008$	$M = 1.629, SD = 0.906$	$M = 1.669, SD = 1.010$

Table 4: Measured data in the UEQ

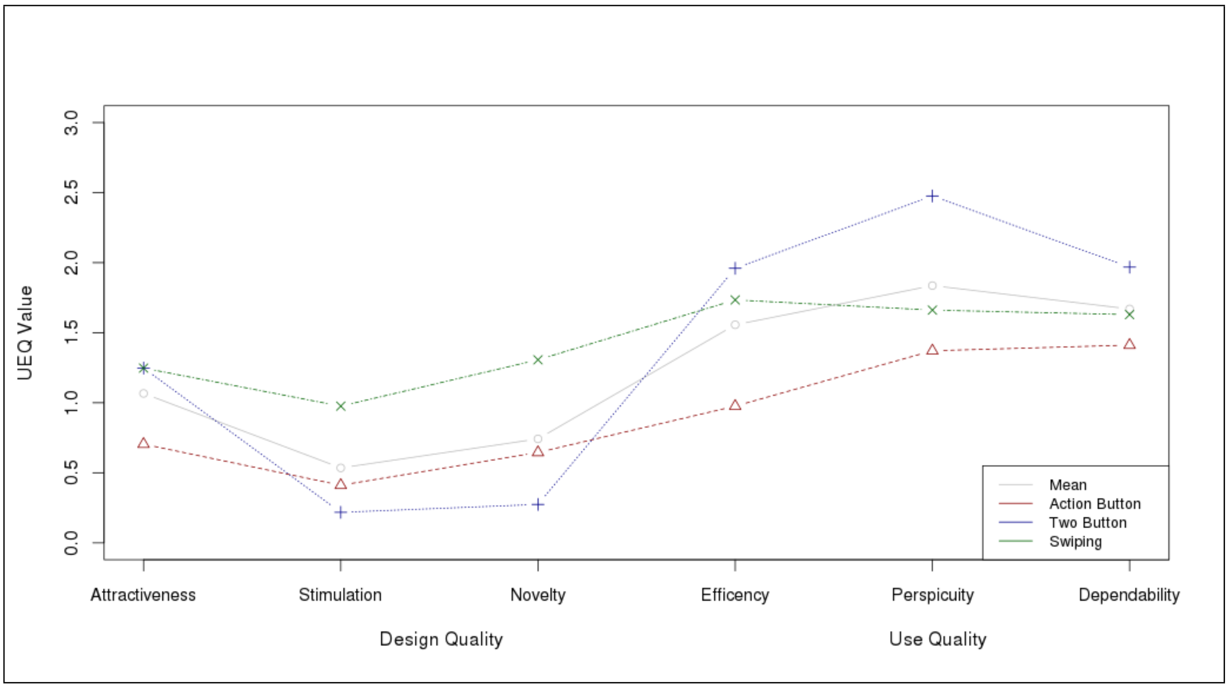

Figure 12: UEQ values for depending on the interaction method

mentioned after the study that the SW method reminded her of the smartphone application Tinder. The fluency with applications using this interaction method might affect how users perceive such interaction. Further studies should ask the users, whether s/he uses applications with such interaction methods.

This study was only conducted on the Android platform. Typical interaction methods on other devices, so as the Apple Watch might differ. A study to see, whether the user interaction is perceived similarly on other devices could show how representative these findings are.

Comparing interaction methods on one device can only show differences in using this device. However differences across multiple devices are interesting as well. For example users might like voting on a smartwatch more than on a smartphone. A comparisson across devices is useful to see whether using smartwatches in this use case is beneficial to the users.

For this study each interaction method allowed to vote a recommendation as either positive or negative. To gain more value for recommender systems, a five star rating is used widely. Comparing different methods to create five star ratings on smartwatches can show, how such ratings perform. A possible method is a list, where the user can swipe up and down to choose one list entry depicting several stars. Another method might be five stars on the smartwatch where a swipe from left to right colorizes the stars. Comparison with a two valence voting could complete such a study.

9. REFERENCES

[1] Gediminas Adomavicius and Alexander Tuzhilin. Toward the Next Generation of Recommender Systems: a Survey of the State of the Art and Possible Extensions. *IEEE Transactions on Knowledge and Data Engineering*, 17(6):734–749, 2005.

[2] Andr.oid Eric. Android-er: Detect Gestures of Swipe to switch between activity, 2014. URL: `http://android-er.blogspot.de/2014/12/detect-gestures-of-swipe-to-switch.html` [Accessed 2015-05-12].

[3] Yannick Bernaerts, Matthias Druwé, Sebastiaan Steensels, Jo Vermeulen, and Johannes Schöning. The Office Smartwatch – Development and Design of a Smartwatch App to Digitally Augment Interactions in an Office Environment. In *DIS Companion '14 Proceedings of the 2014 companion publication on Designing interactive systems*, pages 41–44, New York, NY, USA, 2014. ACM.

[4] Pratyush Bharati and Abhijit Chaudhury. An Empirical Investigation of Decision-Making Satisfaction in Web-Based Decision Support Systems. *Decision Support Systems*, 37(2):187–197, 2004.

[5] Marta E. Cecchinato, Anna L. Cox, and Jon Bird. Smartwatches: the Good, the Bad and the Ugly? In *CHI EA '15 Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, pages 2133–2138, New York, NY, USA, 2015. ACM.

[6] Xiang 'Anthony' Chen, Tovi Grossman, Daniel J. Wigdor, and George Fitzmaurice. Duet: Exploring Joint Interactions on a Smart Phone and a Smart Watch. In *CHI '14 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 159–168, New York, NY, USA, 2014. ACM.

[7] Mark D. Dunlop, Andreas Komninos, and Naveen Durga. Towards high quality text entry on smartwatches. In *CHI EA '14 CHI '14 Extended Abstracts on Human Factors in Computing Systems*, pages 2365–2370, New York, NY, USA, 2014. ACM.

[8] Chris Edwards. Watch clever. *Engineering & Technology*, 8(12):30–35, 2013.

[9] Daniel Gallego, Wolfgang Woerndl, and Gabriel Huecas. Evaluating the impact of proactivity in the user experience of a context-aware restaurant recommender for Android smartphones. *Journal of Systems Architecture*, 59(9):748–758, 2013.

[10] Edd Gent. Apple iphone 6 and apple watch finally unveiled. *Engineering & Technology*, 9(9):12, 2014.

[11] Google Inc. Adding Voice Capabilities | Android Developers, 2015. URL: `https://developer.android.com/training/wearables/apps/voice.html` [Accessed 2015-04-27].

[12] Google Inc. Android Wear – Google Store, 2015. URL: `https://store.google.com/category/android_wear` [Accessed 2015-04-27].

[13] Google Inc. Creating a Notification for Wearables | Android Developers, 2015. URL: `https://developer.android.com/training/wearables/notifications/creating.html` [Accessed 2015-04-27].

[14] Google Inc. Design Principles for Android Wear | Android Developers, 2015. URL: `https://developer.android.com/design/wear/principles.html` [Accessed 2015-04-27].

[15] Google Inc. How to use your watch - Android Wear Help, 2015. URL: `https://support.google.com/androidwear/answer/6056770?hl=en` [Accessed 2015-09-18].

[16] Google Inc. How to use your watch - Android Wear Help, 2015. URL: `https://support.google.com/androidwear/answer/6056770` [Accessed 2015-05-11].

[17] Google Inc. UI Patterns for Android Wear | Android Developers, 2015. URL: `https://developer.android.com/design/wear/patterns.html` [Accessed 2015-05-11].

[18] Stephan Hammer, Thomas Rist, Sofia Kastrinaki, Charline Hondrou, Amaryllis Raouzaiou, Kostas Karpouzis, and Stefanos Kollias. Design of a Lifestyle Recommender system for the Elderly: Requirement Gatherings in Germany and Greece. In *PETRA 2015, Affective Computing for Biological Activity Recognition in Assistive Environments Workshop,1-3 July*, Corfu, 2015.

[19] Robert Kabacoff. Quick-R: t-tests, 2014. URL: `http://www.statmethods.net/stats/ttest.html` [Accessed 2015-08-19].

[20] Kiwi Wearable Technologies Ltd. Kiwi for Android Wear – Android-Apps auf Google Play, 2015. URL: `https://play.google.com/store/apps/details?id=com.kiwiwearables.app` [Accessed 2015-05-11].

[21] Bettina Laugwitz, Theo Held, and Martin Schrepp. Construction and Evaluation of a User Experience Questionnaire. In Andreas Holzinger, editor, *USAB 2008 - 4th Symposium of the Workgroup Human-Computer Interaction and Usability Engineering of the Austrian Computer Society*, pages 63–76, Graz, 2008. Springer Berlin Heidelberg.

[22] Justin J. Levandoski, Mohamed Sarwat, Ahmed Eldawy, and Mohamed F. Mokbel. LARS: A location-aware recommender system. *Proceedings - International Conference on Data Engineering*, 1:450–461, 2012.

[23] Haiko Lüpsen. Varianzanalysen - Prüfen der Voraussetzungen und nichtparametrische Methoden sowie praktische Anwendungen mit R und SPSS, 2015. URL: `http://www.uni-koeln.de/~a0032/statistik/texte/nonpar-anova.pdf` [Accessed 2015-08-08].

[24] Kent Lyons. Using Digital Watch Practices to Inform Smartwatch Design. *CHI'15 Extended Abstracts*, pages 2199–2204, 2015.

[25] Paul Resnick and Hal R. Varian. Recommender Systems. *Communications of the ACM*, 40(3):56–58, 1997.

[26] Stack Overflow. How to implement gesture recognition in android wear, 2014. URL: `https://stackoverflow.com/questions/27524418/how-to-implement-gesture-recognition-in-android-wear` [Accessed 2015-05-30].

[27] Wolfgang Woerndl, Johannes Huebner, Roland Bader, and Daniel Gallego-Vico. A model for proactivity in mobile, context-aware recommender systems. In *Proceedings of the fifth ACM conference on Recommender systems - RecSys '11*, pages 273–276, New York, NY, USA, 2011.

[28] Bo Xiao and Izak Benbasat. E-Commerce Product Recommendation Agents: Use, Characteristics, and Impact 1. *Commerce Product Recommendation Agents MIS Quarterly*, 31(1):137–209, 2007.

[29] Taha Yalcin. *Nutzerzentrierte Untersuchung von Benachrichtigungen auf intelligenten Uhren.* Bachelorarbeit, Universität Stuttgart, 2014.

[30] ASUSTeK Computer Inc. ZenWatch. ZenWatch Remote Camera – Android-Apps auf Google Play, 2015. URL: `https://play.google.com/store/apps/details?id=com.asus.rcamera2` [Accessed 2015-05-11].