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STUDYING THE USER ACCEPTANCE OF A MOBILE INFORMATION SYSTEM FOR TOURISTS IN THE FIELD

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In recent years several prototypes and concepts of location-based tourist guides have been developed. Only a few of them have been evaluated by actual users. This article presents the results of a field study in which the user acceptance of two kinds of mobile information systems for tourists was evaluated by means of a questionnaire survey and interviews. The first mode (Planner) provides tourists with a personalized tour, and besides multimedia-based information at the sights, it offers navigation instructions as well. The second mode (Explorer) shows nearby sights and offers multimedia-based information that can be requested manually. The results show that mobile information systems were the most relevant information sources for tourists during their city visits. Furthermore, it is shown that the acceptance of such systems is positive and significantly influenced by the quality (accuracy) of the pedestrian navigation.

Key words: User acceptance; Mobile information system; Pedestrian navigation; Field trial

Introduction

Mobile recommender systems such as electronic tourist guides have the potential to enrich the experiences of tourists visiting an unknown location. Due to the ongoing progress in mobile computing and the development of advanced positioning technologies, the number of location-based information systems within museums and in cities is increasing constantly. For the market success of those kinds of services it is crucial to develop applications that can be used easily by future users. Thus, to capture the market it is necessary to identify the requirements of the target group. Therefore, following the concept of User-Centered Design (UCD) (Norman & Draper, 1986) end user studies within the target group have to be done to measure user acceptance as an indicator for future usage.

Unfortunately, only sparse research has been conducted focusing on the user acceptance of mobile information systems in environments such as towns and cities. A few publications have considered the needs of indoor users and indoor navigation aids, but the development of an outdoor guidance system is different and has its own challenges.

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In addition, most existing digital guides are still concepts or prototypes and have been rarely applied in field trials. This article attempts to improve the situation by presenting the results of an acceptance study in the field with the intended user group itself—real tourists.

Following the UCD principles, a mobile information system for tourists called Dynamic Tour Guide (DTG) was developed (ten Hagen, Modsching, & Kramer, 2005). This mobile guide is context sensitive. In other words, the DTG has knowledge of the physical location and user's preferences. A previous field trial (Kramer, Modsching, & ten Hagen, 2006) showed its ability to elicit generic interests in the mobile context, to select sights and to combine them into an appropriate tour for tourists. In the last phase of the design process a field study with tourists in the city of Görlitz, Germany was conducted to measure the acceptance of the system with an extensive sample.

Important projects that influenced the development of the DTG and the characterization of the DTG application itself are described in the following two sections. The fourth section provides the theoretical background of the user acceptance study and gives a description of the methodology of the field trial. Afterwards, the results of the study and limitations are discussed in the fifth and sixth sections. This article ends with a conclusion and a discussion on future work.

Mobile Tour Guides

Mobile tour guides are the result of years of research in the areas of recommenders, ambient intelligence, and persuasive computing. The following projects mark important influences on the design and development of the DTG application:

- **Cyberguide** (Abowd et al., 1997) was one of the first mobile tour guides. It works outdoors with GPS and indoors with infrared to determine contextual information like the user's position. Personal preferences are not analyzed to compute a tour plan but the user can retrieve information or request a route to a desired Point of Interest (PoI).
- **GUIDE** (Cheverest, Davies, Mitchell, & Friday, 2000) is a mobile tour guide very similar to the DTG. The visitor chooses sights from various categories. Afterwards these places of interest are sequenced taking into account the opening hours, best time to visit, and the distance between the attractions. The sequence can be modified manually. Navigation is achieved by a map with a list of instructions. Unlike the DTG, it uses cell-based positioning instead of GPS and the selection of concrete sights instead of deriving the selection from generic preferences.
- **The CRUMPET project** (Schmidt-Belz, Laamanen, Poslad, & Zipf, 2003) developed a personalized, location-aware, multiagent system. It recommends tourist sights and provides interactive maps and directions to find a selected sight. It is one of the few projects having performed a usability evaluation where users had to complete several tasks observed by a research assistant. The majority recognized the system as added value to conventional information sources and indicated they would be willing to pay for it.

Each of the three guides is a mobile and context-sensitive system that is able to deliver multimedia information to the user. Its presentation of information depends on user requests as is the case in the DTG Explorer mode. In contrast, the DTG Planner computes a personal tour plan. Further, different navigation concepts have been used in these applications, but none employs a standard navigation package including a map, route, and audio instructions like the DTG Planner does.

Dynamic Tour Guide

The Dynamic Tour Guide (DTG) is a mobile application offering two different modes: Planner and Explorer. The Planner mode supports individual, guided tours. Tourists are enabled to specify the desired duration and end point of the tour as well as interests by means of an image button hierarchy or weighting main categories before exploring the city. Because location of restaurants is one of the most important information aspects for tourists (Schmidt-Belz & Posland, 2003), the DTG also integrates restaurants or cafés in its tour planning on the basis of the tourist's preferences. Afterwards, a personalized tour is offered that takes into account the tourist's specifications. In order to support the way-finding, a map including the actual position, the suggested tour, and a photo

showing the next sight from the current direction is visualized (Fig. 1). In addition, the tourist receives audible navigation instructions by an integrated standard navigation application. When the tourist reaches a sight, audio-visual and textual information are provided automatically. If the tourist is leaving the planned tour a dialog occurs that offers several possibilities to adapt the tour (e.g., to remove sights or to prolong the duration of the tour).

In contrast to the Planner mode, the Explorer mode offers no interest capturing, no guided tours, and is not based on a tour plan. Instead, the tourist's free city exploration is supported by providing context-based information whenever requested. Explorer users are shown a digital map with their current position to give an atmospheric insight into the city's build-up. In addition, a continuously actualized list of sights nearby (in a distance of 100 m) is offered to the tourist (Fig. 2).

For both modes the positioning of the tourist is supported by GPS. The two modes represent very different examples of mobile information systems (Table 1) and raise the question whether they lead to differences in the user acceptance of the two modes.

Methodology

Setting of the Field Trial

In order to comprehensively evaluate the user acceptance of the DTG objective and subjective data were collected. To capture objective data interactions of tourists were logged (e.g., time stamps to evaluate the tour duration and GPS positions to examine the covered distances). For capturing subjective data a questionnaire was designed whereby both modes of the DTG were evaluated. A total of 20 mobile devices (MDA III) were connected to an external Bluetooth GPS receiver and equipped with the mobile DTG application and given to tourists at a stand located in the medieval city center. The stand was open daily from 9 a.m. to 6 p.m. in August 2006. The distribution was supported by staff members who were walking through the city and offering the DTG to tourists in less central parts of the city. If a tourist agreed to take part in the study, he/she was given a headset, the necessary hardware to run the DTG, as well as a short technical instruction and a post-test questionnaire. In case a tourist didn't want to come back to the stand, a map with several return stations in the city (e.g., restaurants and hotels) was provided. The completed questionnaires were digitally captured immediately after the trial.

Several interviews were conducted in order to explore the needs of elderly and younger adults using a mobile city guide. After a short introduction, participants were asked about their computer skills, demographics, and expectations about a mobile tour guide. Afterwards they were encouraged to create a tour through Görlitz by means of both modes of the DTG. Upon completion of the

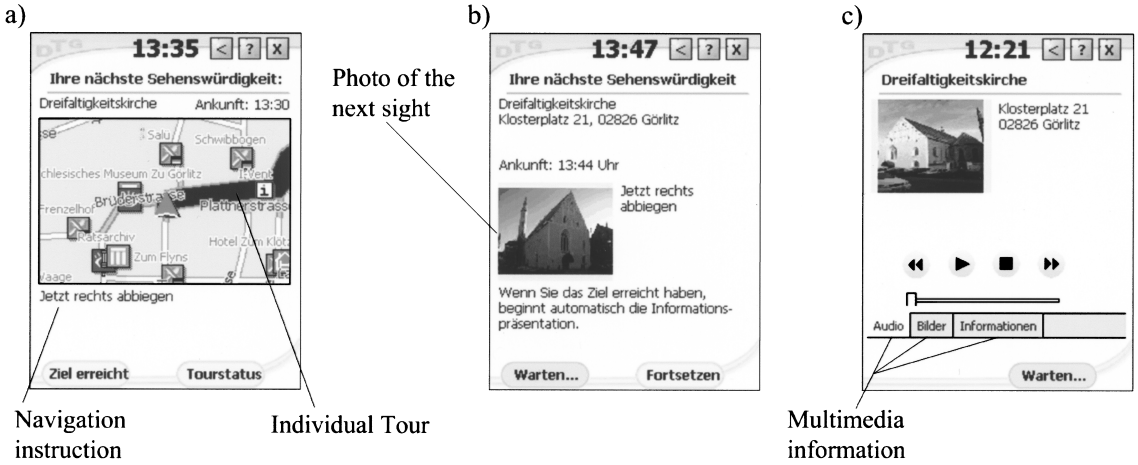

Figure 1. Screenshots of DTG Planner.

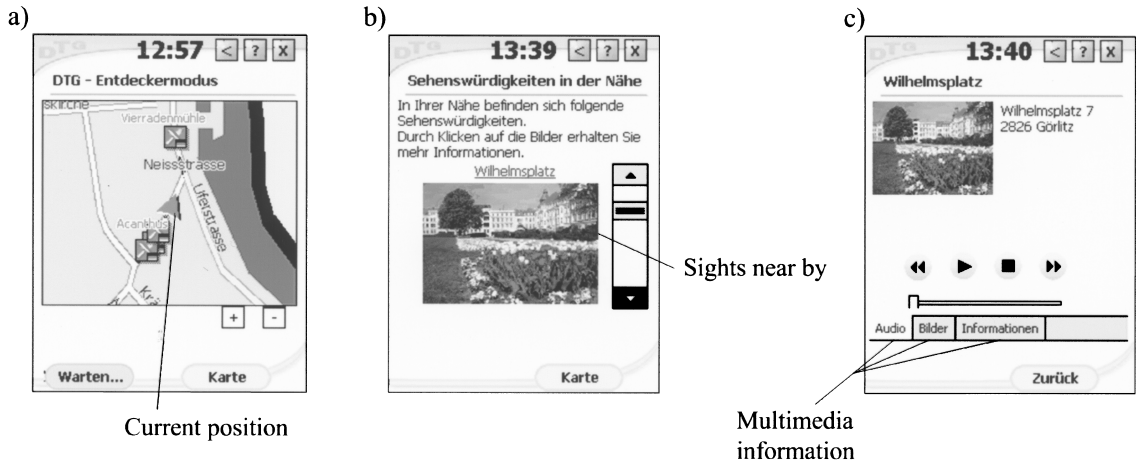

Figure 2. Screenshots of DTG Explorer.

tour, they were invited to report their experiences in a semistructured interview. The debriefing included various questions including what worked well, what went wrong, what features were important, which were missed, importance of the pedestrian navigation, which types of information were important, and, finally, how much they would pay for renting such a system. As a thank you for participating in the field trial each person was either given a city map or a DVD about the city of Görlitz.

Questionnaire

The main purpose of the survey was to measure the user acceptance of mobile, location-based applications like the DTG. The user acceptance can be rated as positive when the user is willing to deal with the system and to use it again. Nielsen (1993) introduced the construct "system acceptability" to analyze the quality of a system (Fig. 3). The questionnaire was based on this as well as international standards relating to usability (ISO 9241-11, 1998). According to Nielsen (1993), acceptability can be divided into the two dimensions: Social and Practical Acceptability. The term social acceptability refers to how well a system suits or is compatible with the social habits of the target group. This means, for example, that the user feels comfortable using the system in public. Practical acceptability considers aspects such as usefulness, cost, support, reliability, and compatibility with existing systems. The cost of the system shall be taxed in a cost–benefit analysis.

Following the framework proposed by Nielsen (1993), the questionnaire included questions about the willingness to rent the system and how much tourists would pay for using it a whole day. The support for the application could not be evaluated as the DTG was not provided as a real service. Reliability of a system means whether users trust that the software is secure and is technically reliable. This issue was not implemented into the questionnaire as the tourists tested the system only once, which is not sufficient to evaluate the reliability of a system. Also, compatibility with other existing systems was not considered as the distribution of the DTG was based on lending the software in a complete package including the required hardware.

Usefulness as another aspect of the practical acceptability can be separated into utility and usability. Utility deals with the functionality of the system, whether the software can perform what is needed. This refers to the usability principle "suitability for the task" (ISO 9241-110, 2006) and is described further below. Usability is specified within Nielsen's model with the following characteristics: easy to learn, efficient to use, easy to remember, few errors, and subjectively pleasing. In summary, these terms describe how well users can use the system's functionality. An advanced model for specifying and measuring the usability

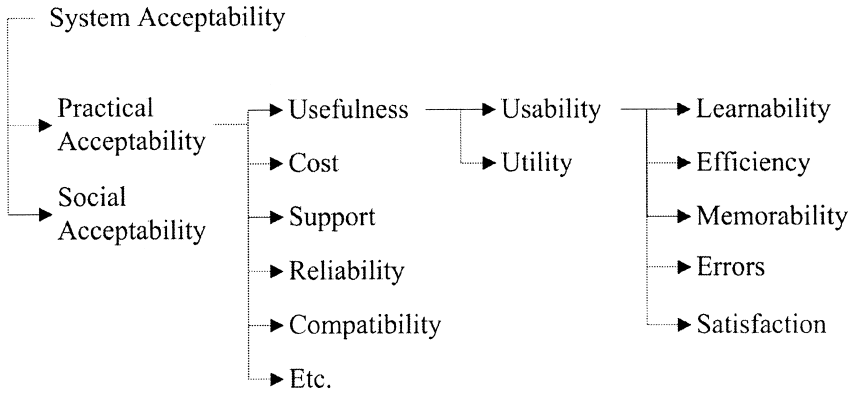

Figure 3. Nielsen's (1993) system acceptability.

of a product is provided by ISO 9241 part 11 "Guidance on usability" (1998). According to ISO 9241-11, usability is defined as the degree to which a product can be used in a specific context by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction. In order to meet these requirements a product has to be designed according to basic guidelines. Therefore, the following dialogue principles as described in ISO 9241-110 (2006) were used as the basis for designing the questionnaire:

- **Controllability:** The user can control the dialog, its direction and speed, up to reaching the goal.
- **Conformity with user expectations:** The system should be consistent and meet user's expectations, knowledge, and experiences.
- **Error tolerance:** The system is error tolerant when the user achieves his goals despite errors in input and the intended result may be achieved without any or minimal correction effort by the user.
- **Self-descriptiveness:** The system provides enough information to describe itself in a way the user understands every dialog step or obtains an explanation on demand.
- **Suitability for learning:** The system supports and instructs the user in learning how to use it.
- **Suitability for the task:** Users should be able to accomplish their task efficiently and easily with the system.

In addition, hedonic quality aspects (Hassenzahl, Platz, Burmester, & Lehner, 2000) of the system as scale 'joy of use" were captured. For an entertainment product as the DTG "joy of use" can be defined as part of utility, too. Previous versions of the questionnaire were intensively tested and revised several times. Thus, the questionnaire contained 33 items and used a 5-point Likert scale that ranged from "strongly agree" (5) to "strongly disagree" (1). Negative items were encoded in reverse order. In addition, the questionnaire included basic demographics such as age, gender, occupation, computer literacy, and some open questions about the choice of a restaurant or café during the city visit.

Table 1
Features of the Two DTG Modes

Features	Planner	Explorer
Elicitation preferences	no	yes
Ranking sights	no	yes
Tour modification	no	yes
Tour plan	no	yes
Navigation instructions	no	yes
Tour adaptation	no	yes
Restaurant selection	yes	yes
Map	yes	yes
Attraction notification	yes	yes
Multimedia presentation	yes	yes

Results

Overview

In total, 274 tourists participated in the field trial and were willing to report about their city visit and answered the questionnaire. Most of them had

never been in Görlitz before (74%) and spent the first day of their visit in town (63%). Only 9% of the tourists were traveling alone; many more tourists were traveling in groups with two persons (60%); the mean size of a travel group was three persons. This is an astonishing result because the DTG was mainly developed to attract individual travelers. The majority of the participants that answered the questionnaire were male (68%). Considering the social groups of the attendees, 65% reported to be working, 17% were retired, 13% were studying, and 4% did not follow a profession.

Altogether, 132 tourists (48%) tested the Planner mode and 142 persons (52%) the Explorer mode. The distribution of age was quite similar between the two groups. The mean age for the Planner group was 46 and for the Explorer group 48 years. Figure 4 illustrates the distribution of age in detail.

It can be seen that the number of participants being younger than 40 years of age was low in comparison to the age groups older than 40 years. In particular, the group of participants aged between 30 and 39 years was quite small (9.9%) among field trail participants. The reason for this age imbalance is that tourists in Görlitz are, in general, of older age. However, these results show that mobile information systems are of interest for elderly tourists, too. Regarding the experience of the sample group with mobile computing technologies, a minority of the participants (22%) reported to own a personal digital assistant (PDA) or mobile digital assistant (MDA). A huge majority (83%) rated their experiences with these devices as very low or low despite of an average of 6 years of experience with mobile phones and 11 years with computers. In spite of the very low experience in dealing with such mobile devices the majority of the participants (60%) felt comfortable handling the application. Nevertheless, less than one fourth complained about difficulties regarding the handling of the device.

A total of 18 persons took part in the interviews, nine aged between 22 and 30 and nine others between 61 and 73. In both groups three participants were female and six were male. Similar to the field trial attendees, they were not familiar with using mobile devices at all; only one had used a PDA before.

Reliability and Validity of the Questionnaire

A user acceptance questionnaire needs to be both reliable and valid in order to be of value to software developers. Using the cut-off point of 0.3 for retaining variables, none of the items had to be deleted. The overall Cronbach's alpha of 0.91 displays the reliability of the questionnaire. To ensure the validity, the questionnaire was developed as described in the previous section.

Usability and Joy of Use

It can be seen that both Planner and Explorer modes were rated positively. Using Mann-Whitney test, significant differences between the Planner and Explorer mode were found for all dimen-

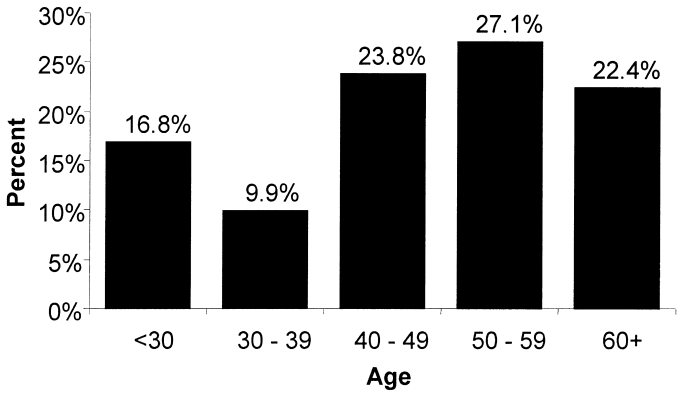

Figure 4. Distribution of age ($N = 274$).

sions except error tolerance. The results are depicted in Figure 5 and include the dimension joy of use.

The results of the *controllability* are due to the fact that Planner users perceived a rigid adherence to a number of input steps, in particular when entering interests and specifications for the calculation of the tour. Altogether, they had to perform four steps until a personalized tour was offered; in contrast, Explorer users only had to start the application and a list with attractions was offered immediately. In both modes a quick access to information and predictable processing times were expected after starting the application. This conclusion is based upon the difference in *conformity with user expectations* because Planner users critically noted that the application acted differently from what they expected, especially with regard to hardly predictable processing times.

The *error tolerance* of the system was rated similar within both modes. The items of this dimension were about the consequences of errors in input and the helpfulness of error messages. Because the help texts were not completely implemented and to most of the participants no error messages were displayed, these items only partly matched the experience of participants and were mostly rated within the middle category of the scale. The difference in the *self-descriptiveness* of the system is caused by the finding that Planner users felt less informed about the status of the system.

Both modes of the DTG received positive results (median = 4.0) in terms of the system's support in learning how to use it. However, the usage of the Planner demanded higher efforts and therefore, decreased the rating of the dimension *suitability for learning* within this group.

With regard to the *suitability for the task*, Explorer users reported higher scores to the functionality of the system; it appears that they had more *joy* using the DTG. These findings could be due to different concepts to support spatial orientation. As Planner and Explorer vary enormously in their way of supporting spatial orientation, this aspect is analyzed in detail in the next section.

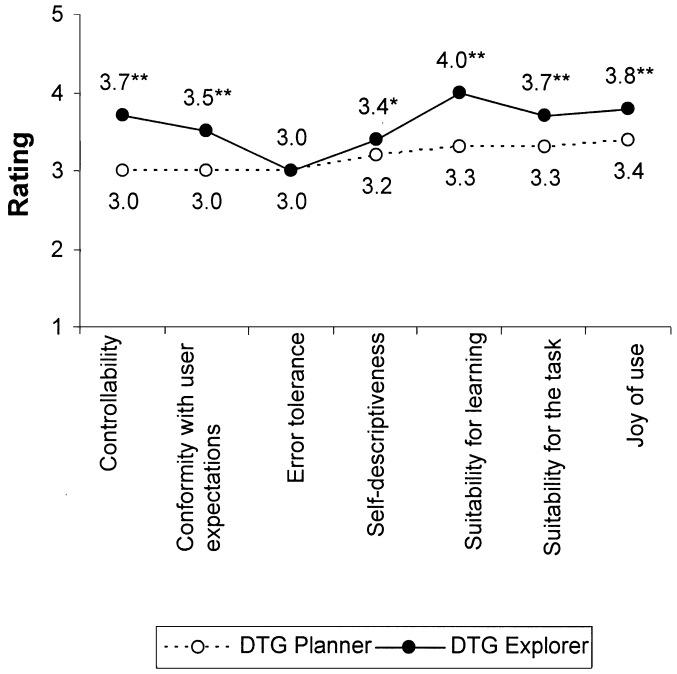

Figure 5. Ratings of the usability scales and joy of use ($N = 274$). The asterisks indicate significant differences between the two groups ($^*p < 0.05$ and $^{**}p < 0.01$, Mann-Whitney).

Spatial Orientation

The evaluation of the spatial orientation in the city results in a heterogeneous picture. That is, while tourists testing the Planner rated their subjective spatial orientation in the city on median with 3.2, Explorer users rated it with 3.7 (differences are significant at the 0.01 level using Mann-Whitney tests). It appears that tourists using the Explorer mode rated their spatial orientation more positive than tourists using the Planner mode. This result can be attributed to the complex interaction with the application for Planner users, and confusing audible navigation instructions due to GPS inaccuracies. Navigational support for pedestrians is supposed to be precise, which is undeniably not possible regarding a measured GPS inaccuracy of 24 m on average in Görlitz (Modsching, Kramer, & ten Hagen, 2006). Within the interview group 12 persons (67%) expected added value of a mobile information system in pedestrian navigation functionality. After testing the DTG 16 persons (89%) mentioned that the pedestrian navigation aid of the Planner was very important for their city visit, but also a number of 13 participants (72%) criticized the accuracy of this functionality and suggested improvements. Therefore, the influence of the spatial orientation on the usability and joy of use of an information system was analyzed. Groups with high and low spatial orientation were determined by employing a median-split procedure. Figure 6 illustrates that there are significant differences between these two groups except for the scales error tolerance and suitability for learning. Participants with high spatial orientation rated the usability scales and joy of use significantly more positive than tourists with low spatial orientation. This confirms the assumption that user acceptance and joy of use are influenced by the spatial orientation and therefore by the quality (accuracy) of the pedestrian navigation functionality.

Usage of the Mobile Information System as a Source of Information

Of particular interest was the extent to which the DTG was used as a source of information by tourists. A majority of DTG users (in the Planner group 78% and in the Explorer group 77%) indicated that they used the DTG as the most frequent medium to gain information about sites throughout the city. Information panels (74%) and guidebooks (65%) were ranked second and third in both groups. The median satisfaction with the quality of the information was positive (median = 4.0) for both groups. This result is not surprising because Planner and Explorer users received information from the same database.

Participants of the interviews were also asked to indicate which type of information (audio, photo, or text) they found most useful; all participants indicated a preference for audio files. Text information was second, while photos were said to be less important. It appears that instead of watching digital photos, participants preferred looking at the real scenery, mainly because of the small screen of the MDA III (50%). As audio information was of greatest importance to tourists, logging data were analyzed to figure out the amount of effectively requested audio files during the field trial. It turned out that Explorer users listened to three times more audio files than the Planner users. This can be explained by the concepts of the two modes: while the Planner provides a complete tour according to the interests of a tourist, the Explorer offers a list of all sights in a distance of 100 m. Unfortunately, at this point no analysis of correlation between requested audio information and user acceptance was possible, because logging data could not be assigned to the regarding questionnaire data.

Analysis of Distance, Duration, and Restaurant Visits

The median length of the Planner tours was 3.4 km and it was 4.4 km for the Explorer. The distance covered by the Planner was, thus, the shortest due to tour optimization by the tour planning component that provided navigation instructions. Tour duration was set on 2 hours by default. Most participants (60%) accepted the default value during the first week. To find out if that is, indeed, the desired duration, the default option was doubled to 4 hours for the rest of the trial. This caused changes regarding the requested durations. In the first week the default value of 2 hours sounded about right and was overwhelmingly accepted. The new default value of 4 hours was way too long and thus

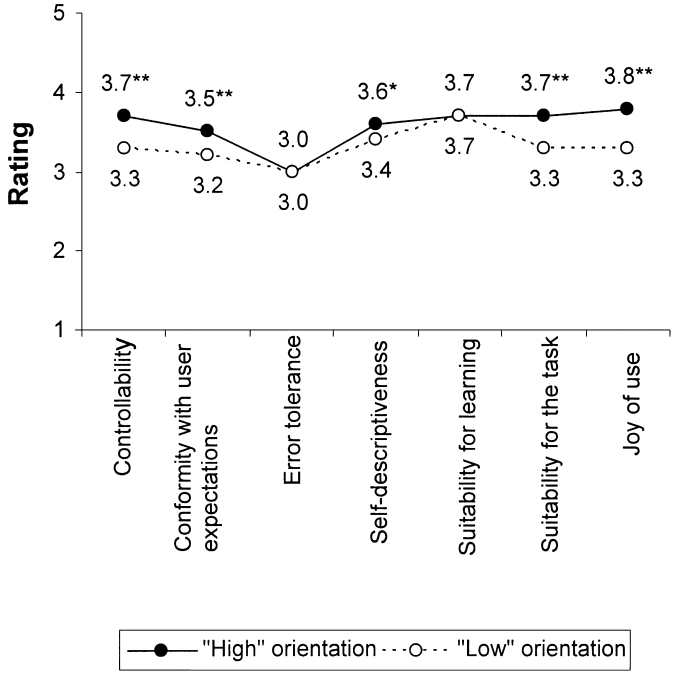

Figure 6. Ratings of the usability scales and joy of use compared to spatial orientation ($N = 274$). The asterisks indicate significant differences between the two groups ($*p < 0.05$ and $**p < 0.01$, Mann-Whitney).

the tourists reduced it to a more reasonable value. Actual tours using the Planner had a median duration of 1.3 hours while the Explorer application was used for a median duration of 1.7 hours.

A restaurant or café was included by the Planner mode for a number of 117 tourists. But only 7% of these restaurants were visited during the tour. According to the questionnaire causes were that 65% did not visit a restaurant or café at all during the tour and 35% spontaneously visited a different location along the way. This might be due to the fact that the mobile applications were called "Tour Guide" and therefore used as such or that the 1.5-hour format suits fundamental user requirements about a sightseeing tour. In general guided tours do not include a restaurant break. That is why tourists might think of it as a separate activity they cannot combine.

Reusing and Renting Intentions

Finally, participants were asked whether they would use such an information system again and how much they would pay for using it a whole day. Altogether 63% ($n = 165$) of the tourists indicated that they would use the DTG again. Examined separately, 70% of the Explorer users and 54% of the participants within the Planner group would use such a mobile information system again. Follow-up questions asked the respondents their willingness to pay for use of the DTG. The results indicate that participants having used the Planner would pay, on average, 4.16€ for using the DTG while Explorer users would even pay 4.50€ for renting the DTG. Comparing the age groups, tourists aged below 30 years would pay the most for renting such a system per diem (Fig. 7). Within all age groups, except the underrepresented group of the participants aged between 30 and 39 years, the tourists would pay more money for the Explorer than for the Planner, which could also be an indicator of dissatisfaction in terms of the lower quality of the navigational instructions. Because Explorer users listened to three times more audio content than Planner users, this issue should also be considered as an influencing value

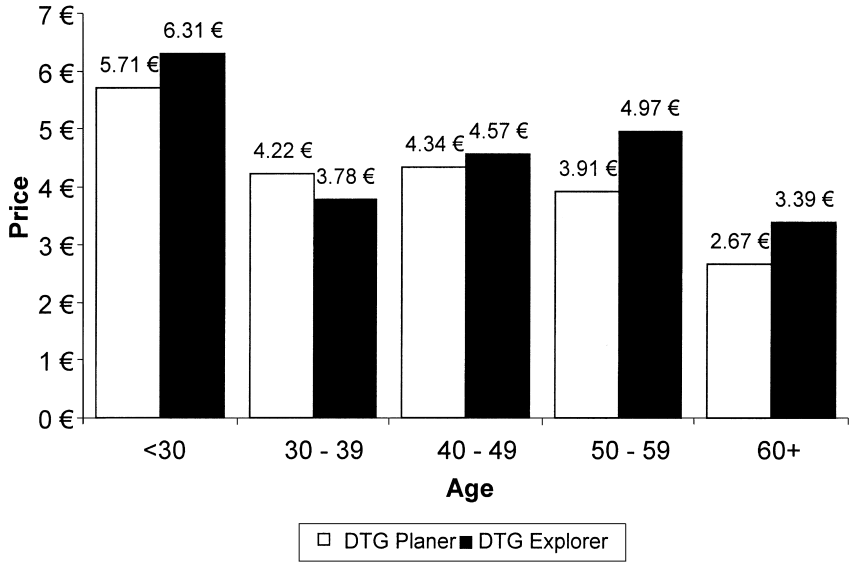

Figure 7. Price for using the DTG for a whole day by age distribution ($N = 274$).

on the price tourists were willing to pay for a mobile information system.

Results of the interviews point out that there is also marketing potential for mobile information systems above the 5€ limit. While seven interviewees could imagine paying a sum between 5 and 10€ for a whole day, four others were willing to pay more than 10€ to a maximum of 30€. In addition, seven persons commented that the price for renting the DTG should be comparable to the price of traditionally guided city tours.

Limitations

During the field trial several tourists also visited indoor attractions like museums or churches. When they entered a building no GPS signal was available. By leaving the site often the synchronization between the external Bluetooth receiver and the MDA III failed and the system crashed. If this happened, Explorer users were asked simply restart the application while Planner users had to specify their interests and preferences again. These incidents were not captured within the logged data but were reported by several participants; it is conceivable that this issue also caused lower user acceptance among the Planner users. Also, to confirm the validity of the user acceptance questionnaire it could be hypothesized that there should be relatively high correlations with similar questionnaires. Due to the lack of standardized questionnaires that measure user acceptance in the mobile context, this was not yet possible. Nonparametric tests were used because of the missing normal curve of distribution among the variables of the questionnaire, as a necessary precondition for conducting parametric tests. Nevertheless, the results from the Mann-Whitney test are significant and a Mann-Whitney test is accurate enough to conclude that significant differences exist between the two groups.

Conclusions

This study examined the user acceptance of two kinds of mobile information systems for tourists under real conditions. Altogether, 274 tourists participated in the field trial. The results indicate that tourists used the DTG as the most important source for gathering information about interesting places and sights during their city visit. It was also found that mobile information systems are also of interest for elderly users, in spite of their lack of experience in using mobile computing technologies. Concerning the aspects usability and joy of use, the Explorer mode was rated slightly better

than the Planner mode. Therefore, it can be reasoned that the Explorer achieves a higher acceptance than the Planner. A significant difference between the two modes occurred in the evaluation of the user's spatial orientation. Those who tested the Explorer mode rated their spatial orientation more positively than those who tested the Planner mode. In the case of user satisfaction with the provided information no differences occurred. This was expected because both systems provided identical multimedia contents. However, differences occurred in the willingness to use such a system again and in the prices the tourists were willing to pay for such a service. That is, those who tested the Explorer mode were more willing to use such a system again and would pay more than the ones who tested the Planner mode. Interestingly, only 9% of the tourists visited the city on their own; most were couples or groups. Advanced concepts of mobile information systems should take this into account and provide extended services to serve groups of tourists (e.g., to combine multiple preferences or to support social communication between groups).

The median distance covered in both groups varied between 3.4 (Planner) and 4.4 km (Explorer), whereas the duration of a tour varied between 1.3 and 1.7 hours. Both modes were accepted for a single activity—a city tour—similar to traditional guided tours. For tourists that spend more than half of a day in a destination, this single tour might be the first one with others to follow. For these subsequent tours the "Tour Guide" paradigm needs to be reframed. These findings also indicate that it might be useful for mobile tourist information systems to provide both modes as exploration might be preferred to get a first impression of the destination, but personalized recommendations might be desired once the most popular and obvious sights have been visited.

Acknowledgments

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