Interaction of Mobile Devices with Product Information – A Comparison of Identification Modalities

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ABSTRACT
Both purchasing products on the Internet and shopping in the real world have their advantages. We conducted an online survey with 136 participants, showing that users see complementary advantages in shopping online and in visiting physical stores. We see great potential in transferring concepts successfully applied by online shops to mobile devices, enriching the shopping experience in the real world. For this, a key challenge is the identification of products. In a study with 17 participants we compare five input modalities (two manual, barcode, two RFID) of mobile phones for accessing product-related information. Our study shows advantages of automatic identification in general, and in particular of RFID. The variables evaluated are interaction speed and ease of use.

ACM Classification Keywords
H.1.2 User/Machine Systems. H.5.2 User Interfaces: Prototyping. K 4.4 Electronic Commerce.

INTRODUCTION AND RELATED WORK
Over the past years, online shopping has gained popularity as it offers a convenient alternative to traditional stores. On the Internet, consumers have easy means to compare prices, learn about products, and read consumers reviews. Revenues in online shops are increasing, but nevertheless physical stores retain their attractiveness to customers. The overall shopping experience created in a shopping mall or a corner store is very different from shopping with a web browser. In this paper we report findings from an online survey with 136 participants that show which values, benefits, and disadvantages users attribute to online purchases and traditional shopping, indicating that mobile data access could improve the shopping experience in the real world.

The enabler for mobile data access while shopping is a new generation of handsets with extended capabilities. On the one hand mobile Internet access has become available at a reasonable price; on the other hand phones with cameras that can be used as barcode scanners [1, 10] and RFID-enabled phones [2] have penetrated the market and allow for new forms of interaction with products. Several projects from both research [3, 4, 5] and business practice [6] take advantage of these facts by devising new applications for mobile phones that improve the in-store experience.

In this context, the choice of appropriate product identification technology for mobile phones is essential. To assess user preferences for product identification, and to measure the interaction times required, we conducted a study with 17 participants. We compared two types of manual input, bar code scanning, and two RFID-based techniques for product identification on mobile devices.

While many have suggested that mobile phones may be the ideal candidates for enriching real-world interactions with information from the Internet, our research aims at gaining more insights into the following question: Which input modality – manual, barcode or RFID - is preferred by mobile phone users in the context of shopping? We build upon Ballagas et al. [7], who have explored and classified various input modalities. Our work goes beyond this by comparing these modalities in a quantitative manner.

In this, our approach is similar to the work of Broll et al. [8] as well as to the study of Rukzio et al. [9]. Both analyze and compare input techniques for interacting with the physical world. According to these studies, touching (e.g. NFC) and pointing (e.g. barcode identification, image recognition and EPC Tag Scan to some extent) are the preferred techniques if the object in question is within the reach of the user. We leveraged these results in our selection of modalities to be evaluated.

Our contribution extends the state of the art in two ways. We contribute:

1. a **quantitative** evaluation of the identification of **products**
2. an examination of the effectiveness of **manual and automated identification** in the context of a **product comparison** task

In the following we highlight the results gathered through the online survey, motivating the set-up of a user study comparing five interaction modalities. Finally we disclose the results of the comparison of automatic identification techniques and manual input for product comparison.

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SURVEY

To understand what properties users appreciate as well as what shortcomings they see when comparing online-shopping and real-world shopping we conducted a web-based survey. The questionnaire consisted of 20 questions and it took about 20 minutes to complete. Users were recruited via email (friends, colleagues, friends of friends, RFID researchers). In total we received 136 responses (25% females) of people of mixed backgrounds from 15 countries on 4 continents. The age range was between 18 and 50+.

The responses entered showed that a large majority of people sees, among others, the following advantages for physical shopping (numbers refer to the purchase of a digital camera):

- you can touch and feel the product (64%)
- you can come back to the store in case of a problem with the product (57%)
- you have the product immediately / no shipping required (15%)

For online-shops the users reported the following benefits:

- easy price and product comparison and hence getting a better deal (60%)
- easy access to technical details, in-depth reviews and customer comments (52%)
- convenience of not having to go shopping in person (29%)

Additional product information is particularly valued for higher priced goods (e.g. consumer electronics) and so called experience products: products dominated by features that can only be fully appreciated after purchase (e.g. wine, books). The responses in the survey showed that participants would value having the benefits of online shopping while being in a store. 79% stated they had already searched for information online, but in the end purchased the product in-store. Exactly this information can be made available on the mobile phone. This finding motivated our experiments, which are described in the following section.

STUDY

The study consists of two parts. First, the participants performed a quantitative and qualitative comparison of five product identification techniques on mobile phones. Second, a product comparison task with two products using two different product identification techniques was evaluated.

Participants

We recruited 17 participants (6 female) for the study. Their average age was 27.5 years with mixed professional backgrounds. All participants owned a mobile phone and were familiar with traditional text input on mobile devices.

Study Design

We utilized a within-subject design. The dependent variable was the time required to identify a product. In the experiment we used 4 different wine bottles (denoted as A, B, C, and D) as the products to be identified. The choice of products was motivated by the following reasons: the survey suggested that wine is a product predominantly bought in traditional shops and the individual products can be easily identified by name. Also, consumers rely on additional information for wine purchases, such as recommendations from friends and test institutes. The independent variables were the following identification techniques:

(1) **Manual Barcode Entry** denotes the manual entry of the number that is located below a barcode. We used a smart phone (Nokia N95), which is well suited for inputting numbers, with a simple application allowing the user to enter barcodes (EAN8, UPC12, EAN13), pressing a button for confirmation and receiving a short feedback that the product was identified.

(2) **Manual Product Search** required the user to type a search term for the given product. For this condition the iPhone was used, as it is widely used for access to the mobile Internet. In contrast to many other phones it offers a fairly large on-screen keyboard. For comparability reasons, we only measured the time the used needed to enter a search term until he pressed the search button.

(3) For **Automatic Barcode Recognition** the participants used a smart phone (Nokia N95) with a camera. For the task a simple application based on a barcode recognition toolkit [10] was used. Users had to scan the barcode by moving the product's barcode into the field of the lens coverage of the handset's camera at a distance of about 3 centimeters. They received feedback when the barcode was recognized.

(4) **NFC Tag Scan** was implemented with a simple Java application using JSR 257 on a Nokia 6131 NFC handset. The latter is a commercially available phone with an integrated HF-RFID reader. Performing the task required the user to touch a tag with mobile phone antenna. The reading range is about 5 cm The user received sound feedback as soon as the tag was recognized.

(5) **EPC Tag Scan** was done on a prototype phone (Nokia E61i with integrated UHF RFID tag reader) using a simple Java application. To identify the product the user had to point the phone towards the product (reading range up to 50 cm).

In the beginning, the participants received an oral introduction (roughly 10 minutes) to the different identification techniques and were encouraged to try them out. Users tested each technique a couple of times until they confirmed that they felt familiar with each. We briefly motivated the use of product identification techniques on mobile devices with potential application scenarios. Each user was encouraged to use the Think Aloud method [11] during the experiment, thus expressing how he felt performing the task. After this, the participants completed

two tasks. Following the study, we conducted an interview with each of the participants.

For each participant the study was recorded on video. In a later step we extracted the precise time recording for the identification techniques from the video. We also transcribed all comments the participant made during the study.

Task 1 – Product Identification

The task for the participants was to use every identification technique (1, 2, 3, 4, 5) on each product (A, B, C, D). In total, each participant performed 20 identification tasks, their order was randomized. Overall, task 1 took about 10 minutes per participant.

Each of the 20 identifications was performed in the following steps: A mobile handset with the software supporting the respective identification technique was handed to the participant. The identification application was active in all cases. As soon as the participant confirmed readiness, the supervisor touched one of the four bottles in order to indicate for which product the identification task should be performed. Touching the bottle is also used as a trigger to measure time. The participant then identified the product. As soon as the product was identified, time recording was stopped. The mobile phone was returned to and reset by a supervisor.

Task 2 – Product Comparison

In the second task we compared one manual and one automatic identification technique. We selected the two techniques which in our experience were most convenient and fastest for the users: Manual Barcode Entry (1) and NFC Tag Scan (4).

Each participant performed the comparison task (for time reasons) only with three randomly chosen bottles (A, C, and D) once with each technique. Half of the participants began with technique 1, before performing the task with technique 4, and vice versa. As in task 1, each participant was given a handset with an active application which allowed identification with the respective technique. After a trigger signal, the participant identified the three bottles in a row. With the confirmation of the last identification (beep) the time recording was stopped.

We measured the time the participants needed for three subsequent identifications using each technique and evaluated all comments made during the experiment by video analysis.

Interview

After having performed the above tasks, we asked each participant to rate each identification technique on a Likert scale from 1 (very hard to use) to 5 (very easy to use). We concluded the interview with an informal discussion about the individual techniques encouraging participants to share their insight and ideas. Finally, we clarified the concrete intention of the study to the participants.

RESULTS

The experiments provided quantitative as well as qualitative information on the different identification techniques.

Automatic Identification is Significantly Faster

Measuring the time per single product identification (task 1) indicates that automatic identification is significantly faster than manual techniques (see Figure 1). From the comments during the study it became apparent that manual input is not really considered as a real alternative when searching for product information on mobile phones. Participant P2 highlighted this as he said "*why do you bother to do the test, it is clear nobody's gonna do this*".

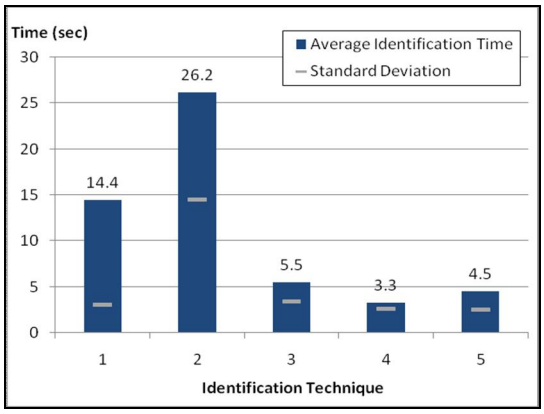

Figure 1: Average Time per Identification by Technique

The fastest identification technique in the experiment was the NFC Tag Scan (4), which took the users 3.3 seconds in average to identify a product. Scanning NFC Tags was time-wise followed by EPC Tag Scans (5), which took the average user 4.5 seconds. In this context it is worth mentioning that, at the current technical level, NFC tag scan (4) and the EPC tag scan (5) interact with products in the same way – by touching the tag on the product with the antenna integrated in the phone. Although both RFID-based identification techniques (4, 5) were the fastest, they were relatively closely followed by the third automatic identification technique, the automatic barcode recognition (5.4 seconds on average). To sum up, all automatic identification modalities are close to each other in terms of time per identification. In contrast, manual barcode entry took approximately three times as long as recognizing the barcode automatically. Moreover, the technique that took the users by far the longest time was entering product information on a search page (2), taking eight to nine times as long as scanning an NFC tag. The large temporal deviations of technique 2 are due to the fact that each participant could freely pick the term considered best suited to find information about the product on hand, leading to search terms of between 7 and 31 characters length.

Time Sums up Comparing Products

The time for three identifications in a row (task 2) was performed by means of manual barcode entry and NFC tag scan. Comparing three products can be considered a typical task during a buying decision. While the automatic

identification of three products takes 8.4 seconds on average, the manual identification is with 39.2 seconds significantly slower.

Correlation Between Ease of Use and Speed

All participants of the user study rated each identification technique on a scale from 1 to 5 (see Figure 2).

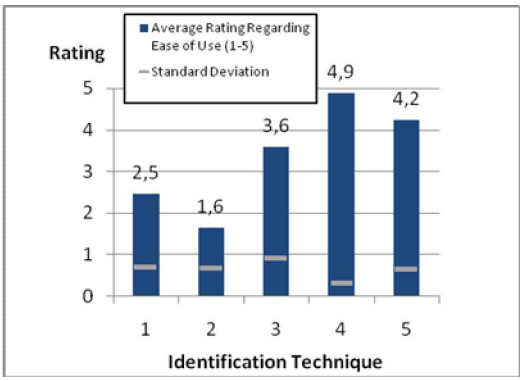

Figure 2: Average Rating per Identification Technique

The NFC tag scan (4) is perceived as the easiest-to-use identification technique with an average score of 4.9 and only two people not rating it at 5. The EPC tag scan is slightly behind (4.2), with some more distance to barcode recognition. The manual identification techniques are according to the user ratings significantly harder to use.

Ordering the identification techniques by speed results in the same order as ranking them by user preference. This indicates a strong correlation between the time needed for identification using a particular technique and the perceived ease of use. Interestingly, three out of six female participants of the study found there was not a big difference in the ease of use of entering a barcode manually and recognizing it automatically.

Variable Attention Requirements per Technique

Observing the participants performing the tasks we noticed large differences in the attention a user needs to use the different techniques. In particular identification technique 4 and 5 were done with little effort. Participants stated that they could imagine technique 1, 2, and 3 being serious hurdles for people with limited attention capabilities.

CONCLUSION

Our survey showed that users see different advantages for online shopping and traditional shopping. In particular the ability of visually inspecting, touching and smelling products is seen as important and hard to replace on the Internet. Using mobile devices and providing easy means of product identification can help transferring services valued by users in the online world to brick-and-mortar stores.

We have compared different techniques for identification of products using mobile phones and our results indicate that automated techniques are significantly faster and easier to use. The gain in time plays an even more important role in tasks where several products have to be identified (e.g. product comparison).

From the interviews we received feedback that easing the interaction by automatic identification changes the user experience completely and users found it very intuitive to use. Especially the observation that identification does not require much attention lets the users focus on the products and on the information from the lookup.

At first it seems that 5 seconds for automatic recognition and 15 seconds for manual bar code entry make no big difference as time spent for shopping is typically minutes to hours rather than seconds. However, for the ease of use the time difference plays a significant role. Lowering the hurdle for accessing product related information seems very important to make it also worthwhile for low involvement products.

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anonymized.

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