User Perceptions on Mobile Interaction with Visual and RFID Tags

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ABSTRACT
In this paper, we present a study of user perceptions on mobile interaction with visual and RFID tags. Although mobile interaction with tags has been proposed in several earlier studies, user perceptions and usability comparisons of different tag technologies have not been intensively investigated. Our field study charts currently existing user perceptions and reveals potential usability risks that are due to the limited or erroneous understanding of the interaction technique.

Categories and Subject Descriptors
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Human Factors.

Keywords
Mobile interaction, user studies, RFID, visual tags, physical interaction.

1. INTRODUCTION
Interacting with the physical world via a mobile handheld device is a relatively new paradigm, which has quickly emerged during recent years. Several factors have contributed to this development trend. Technological advances in mobile devices such as component miniaturization and diminished energy consumption have enabled development of gadgets that have more features and computing power. Integrating cameras, motion sensors, and radio frequency identification (RFID) or barcode readers have made new interaction concepts possible. Mobile devices have become extremely common, as mobile phone adoption rate approaches 100% of the population in numerous countries. Moreover, a mobile phone is typically carried with the owner [2], and thus offers a personal computing platform that is practically constantly accessible by the individual user. Due to these factors, mobile phones hold much potential as a platform for accessing ubiquitous computing services and interacting with smart environments.

Tags utilizing different technologies have been introduced for interacting with physical objects in a variety of applications and uses. For instance, augmented reality applications have been demonstrated [9], gesture recognition based on visual tags has been performed [1], and tags have been used for annotating the physical environment [4]. The use scenarios also include accessing information through interacting with a tag or using the tag for initiating some other information channel, *e.g.* Bluetooth or internet connection [3, 6, 7]. In [5], users were taught the use of a mobile exhibition diary application, where diary entry locations were identified with visual tags placed around the exhibition area.

Typically, interaction with a tag employs physical gesture where the user (or more precisely, user's device) points at or touches a tag, which can be for instance an RFID tag recognized with a device integrated reader or a visual tag read with a camera [6, 7, 8]. Most of the research focus so far has been concentrating on creating new concepts, or utilizing tags as part of a larger system, as opposed to specifically studying the interaction paradigm itself. Typical for the existing studies is that they are often used as a proof of concept with only a small sample of users, often in a non-authentic environment, with guided instruction prior to performing interaction tasks. There exists very little data on how users would interact with tags without any specific instruction, their expectations of the technology, and their perceptions regarding interacting with these objects in public places. The goals of our study, conducted in an 'everyday life environment' (an outdoor pedestrian shopping mall) was to assess the current knowledge or expectations people had with the tag technology, the intuitiveness of usage, social acceptability, and to predict any potential barriers to use. We uses two types of tags, RFID and visual 2D barcodes, and compare the results gained with each.

2. DESIGN OF THE STUDY
The study consisted of interviews, which were carried out in the city center of Oulu, Finland, in June 2006. The interviews were held on a pedestrian mall next to a busy shopping area at the city center. Participants were chosen from those present on the street, to achieve a balance of male and female, with ages ranging from teenager to middle aged (50+). Although the interview was designed to last for five-seven minutes, most interviews ended up taking more like ten minutes, and several lasted for more than twenty. This discrepancy was due to the unexpectedly enthusiastic response of participants to this technology. The interview language was Finnish, or if not spoken by the interviewee, English.

During the interview, each participant was shown two posters, one employing an RFID tag and one a visual tag, see Figure 1. Participants were first asked about their familiarity with a particular tag technology, and then given a brief easy-to-understand explanation of how the tag works (though they were

not told how to interact with it). The participant was asked what kind of information they would expect to receive from the tag, and then given a properly-equipped mobile phone and asked to demonstrate how they would interact with the tag, Figure 2. Answers to the interview questions, as well as observations on usage were recorded by the researchers. After the user had tried to use the tag and was shown the proper usage scenario, he or she was asked to reflect on the intuitiveness and ease-of-use of the experience. For each participant, this process was repeated with both types of tags. To avoid bias the order was altered so that half of the participants started with RFID, half with visual tags.
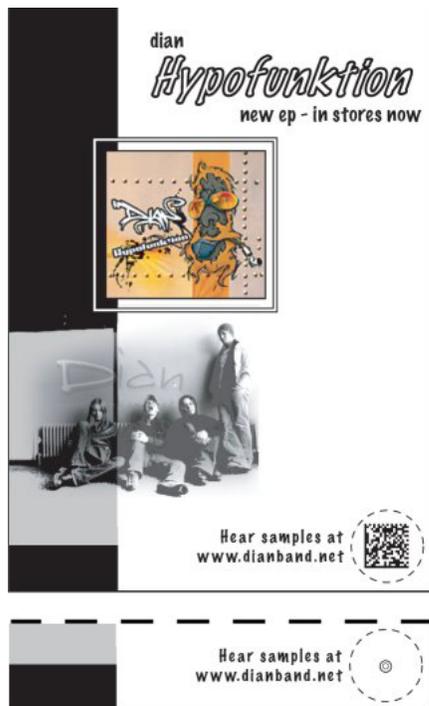

Figure 1. The poster used in the study. Above the complete poster with the visual tag, and below the lower part of the RFID poster (tag is behind the paper).

Figure 2. A study participants reading RFID tag with a phone

The study included 26 participants (11 female, 15 male). All study participants happened to own a mobile phone. The background information of the participants is presented in Tables 1 and 2.

Table1: Age distribution of the participants

Age	No. of participants
<20	8
20-29	8
30-40	7
>40	3

Table 2: Mobile phone usage of the study participants

	Yes	No
Carried currently a phone with:	25	0
Owned a camera phone:	12	13

3. RESULTS

3.1 General perceptions

In the study it was found that the used tag technologies were generally unknown to the participants, see Figure 3. A large majority of the interviewed were not familiar with the concept of either the RFID or visual tag, although for some, RFID tags were known from security tags on clothing or compact discs. Despite of visual recognition of the tag, they were not aware of their usage in the current context. In general the participants were receptive and enthusiastic towards the presented information acquisition methods and came up with suggestions for novel applications. The responses indicated a general sense of openness towards new technology, and eagerness to incorporate it into their daily lives.
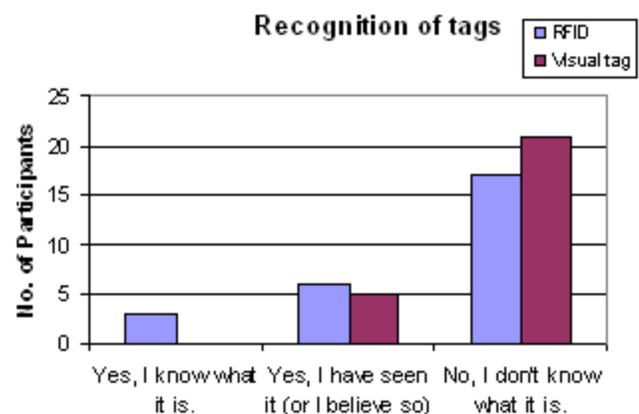

Figure 3. Participants' answers in if they recognized what the tags were or if they had seen them earlier.
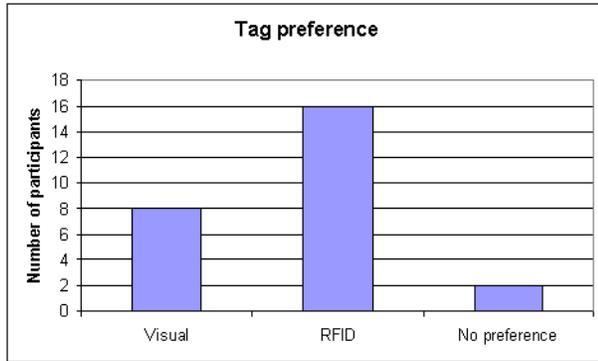
Figure 4. Participants' preferences for the tags.

3.2 Establishing a mental model

3.2.1 Physically interacting with the tag

As physical tags were mostly unknown to the participants, they had no prior experience on which to base their interactions with this technology, other than the brief description of the technology which we supplied. It was apparent from the interviews that the participants had developed a diverse range of mental models governing what kind of information the tags could store, and how that information could be transferred to their mobile phone.

Visual tag For the visual tag, once it was established that it was just ink printed on the surface of the paper, most users deduced that you need to use the camera to access the information. Some users suggested that they actually needed to take a picture of the visual tag, while others just pointed the camera at the tag and waited for it to register automatically.

RFID tag Given its decreased visibility (*i.e.* hidden behind the paper), and more advanced technology, it makes sense that the appropriate interaction technique with the RFID tags proved slightly more elusive for participants. When asked how they would interact with the RFID tag, responses included utilizing text messaging, Bluetooth, manually opening up a URL in a mobile browser, reading it via an infrared port, calling a stored number to hear pre-recorded information, and taking a picture.

3.2.2 Tag content vs. context

One issue that people were unclear on is the distinction between the content of the tag and how the phone will actually utilize that content. When asked what information the tag may contain, many users correctly guessed it would contain band-related information, and some suggested specifically that the tag may contain an mp3 file. One user even asked how much data the RFID tag can hold. One element of the descriptions that was missing was that the participants did not specify what the phone would actually do with that information. Implicit in many participants' responses was that the phone would just store the information for later use. No one actually stated explicitly that the tag could open a specific webpage in the browser on your phone.

3.3 Comparison of user preferences

Sixteen out of the twenty-four study participants preferred the interaction paradigm of the RFID tag, while the remaining eight preferred the visual tag (Figure 4).

RFID tag The RFID swipe was viewed as being quicker, taking less effort, and generally feeling more natural than taking the picture of a visual tag. Those that favored RFID also liked that it did not require opening any additional application. However, some people had reservations about the 'active' broadcast nature of the RFID, and worried that they could be picking up RFID information without intending to.

Visual tag Those that preferred the visual tag stated that the physical action of taking a photo is more comfortable and socially acceptable than waving your phone on the wall.

Aesthetic considerations There were also differing opinions with respect to the aesthetics of the two different types of tags. Some people disliked the way the visual tag looked, saying that it was too "official" or technological looking, while others praised it for its sleek look, and said that they thought it made the poster look cooler. Based solely on the appearance of the visual tag, one female participant decided that she would not be able to use the visual tag because she was "not a mathematical person".

Interestingly, several participants actually expressed concern about adoption issues, thinking from the perspective of those who would be using the tags as information producers. They preferred the visual tags because they were cheaper to use and caused less waste.

4. DISCUSSION

When a user is faced with any unfamiliar situation, it is expected that he or she will attempt to make sense of the world by developing a mental model based on any prior relevant experience. As most users had not seen either of these physical tags before, we gently introduced the basics of each technology to study participants through understandable analogies. Participants' subsequent demonstrations of how they would interact with the tags represent varying levels of comprehension of the technologies, an important point to take into account when educating users on the availability of services enabled by these technologies, the capabilities of their mobile phone, and considering methods of deploying tags into the environment.

Range and visibility Another characteristic that affected participants' interactions with the RFID and visual tags is their range and visibility. The range of the RFID tags is less than 10 centimeters (approx. 4 inches). Due to this short range of function the user needs to be informed precisely of the location of the tag, although the tag itself does not need to be visible. In the study, the RFID was attached to behind the poster and its location was indicated with visual icon. The visual icon utilized (two concentric circles) was not a commonly known indicator for RFID and did not therefore provide any previously known cues for interaction. As the usage of RFIDs or other invisible near-field communication (NFC) becomes more common, it will be important to develop standardized visual cues, enabling users to easily recognize the presence of an NFC, and execute the known interaction method.

Push vs. pull Judging from participants' responses when we asked how they would interact with either of the tags, it was apparent that some of them did not understand the distinction of a *push* technology (*e.g.*, RFID, which transmits information to your phone) versus a *pull* technology (*e.g.*, visual tags, which require you to seek the information stored in them). Interestingly, although participants had used cameraphones before and were used to the idea of snapping a photo, many had expected the visual tag to be recognized by pointing at it with the camera,

without initiating an explicit capture action. This implies that the users expected the system to be 'sense' the presence of a tag. This kind of behavior of visual tags can be traced back to a mental model of bar codes, as seen in shops counter with laser readers.

One important design goal that can be derived from these findings is that you cannot expect a user to understand the technology behind different physical tags. As the goals of these two types of tags are the same, it will be important to make the content transfer mechanism transparent to users.

Content disposition   Both of the tags were expected to contain direct textual information related to the band presented in the poster. The device and application were considered as a "lens" to view their information content being otherwise in incomprehensible form. The users were surprised when the recognized identifier triggered a browser which then retrieved information from the internet. They did not expect the identifier to acts as reference nor trigger for other applications.

Information persistence   In addition, the information display was expected to be dependent on the proximity with the tag. The tag was held in the scope of the device, either within the viewfinder of the camera or in the proximity of the RFID module even after the actual tag recognition occurred. This observation also supports the concept of the device as a lens to view local information.

5. CONCLUSIONS

User perceptions on interacting with tags have not been extensively studied. If user studies on the interaction paradigm have been performed, they have typically been used for confirming the interaction paradigm selected for a certain application. These studies have commonly employed only a small amount of people, and have typically been performed in laboratory environment, university campus, or with IT students or professionals. In our study, we concentrated on the perceptions people had about visual and RFID tags, with the intent to elucidate the issues related to mobile interaction with them. We conducted and performed a field study where 26 selected participants were interviewed in a city center of Oulu, Finland. The interview sessions also included interacting with a mobile phone and RFID and visual tags.

In the study we found that the large majority of the participants were not familiar with the concept of either the RFID or visual tag and did not have clear knowledge of their application prior to the interview. The tags were assumed to contain direct information in encrypted form and users were surprised on unexpected access to networked data resources.

The study results reveal that there are potential usability risks with the mobile interaction with RFID and visual tags. Currently, the mental model that people have on the technologies is still very vague, and although different concepts of using tags for mobile interaction have been considered in research communities for years and are currently gaining popularity in an enterprise context, the idea has not yet been adopted by large audiences because of the lack of existing commercial consumer applications.

The study showed that there are no existing practices and mental models for the usage of visual and non-visual tags in the studied domain. For comparison we are planning to conduct similar study in other regional location and culture to be able to compare the stage of development and the cultural variables affecting to the usage of the tags. In addition, the development of appropriate visual cues for invisible tags will require more studies.

6. ACKNOWLEDGMENTS

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