User Expectations for Mobile Mixed Reality Services: an Initial User Study

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ABSTRACT

Mixed reality, i.e. the integration and merging of physical and digital worlds, has become an integral part of the ubicomp research agenda. Often, however, in development of first technology concepts and prototypes, the expectations of potential users are not considered, and the development easily becomes technology-driven. To understand the expectations and needs of potential users of future mobile mixed reality (MMR) services, we conducted altogether five focus group sessions with varying user groups. We investigated the early impressions and expectations of MMR as a technology by evaluating various usage scenarios. Based on this initial study, we found relevance issues (what information to receive, how and when) and the reliability of MMR information to be the most salient elements that were anticipated to affect the overall user experience. In mobile and busy situations the MMR information content has to be something that is very important or useful for the user, especially if receiving the information or interacting with it draws the user’s attention away from the tasks executed in the real world.

Keywords

Mobile mixed reality, augmented reality, context awareness, mobile services, user expectations, user studies, scenarios.

ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation (e.g., HCI)]

1. INTRODUCTION

The concept of mixed reality refers to the integration and merging of the real and virtual worlds where physical and virtual objects complement and interact with each other [3]. Broadly defined, mixed reality is understood to cover the extensive continuum between the two opposite, discrete ends of reality and virtuality [2,20]. In practice, it is often implemented as augmented reality (AR), where the real world is augmented with digital (virtual) information, and augmented virtuality (AV), where a virtual world is augmented with real-world information. With AR, perception of the user’s environment can be enhanced, enriched and be made more transparent to the surrounding data (e.g. information, advertising and resources related to places, objects and situations). In this paper, we focus especially in mobile mixed reality (MMR), particularly with means of augmented reality on mobile devices.

A central use platform of mixed reality is the mobile domain which expands the mixed reality services to cover a diverse set of use cases and scenarios in the mobile environments. Due to the rapid development of sensor and communication technology, mobile devices are becoming more and more aware of their environment, user’s context and information resources near-by. Hence, mobile devices have become a fruitful platform for creating and interacting with mixed reality objects and services. A predominant interaction paradigm in the mobile domain is the magic lens [2], where the user may browse the world via the camera view, and access additional information aligned on top of the view. Also data glasses and other head-mounted displays can be used to create a highly immersive experience of the mixed reality environment. Although AR is very visual by nature, mobile devices can enrich the augmentation of real world also with auditory and haptic information (e.g. informing about information affordances in the environment by haptic cues [12]).

For the last decade in HCI, there has been a prominent interest in studying the user experience (UX) of various products and services. It is regarded as a subjective and holistic concept including both instrumental (e.g. utility and usability) and non-instrumental (e.g. joy, appeal, aesthetics) elements that result from the use of a product [10]. The experience evolves over time as user’s previous experiences affect the overall experience of the product [10,15]. If provided at the right time and in the right place, MMR information can assumedly offer the user rich, useful, delightful and positively surprising experiences. However, it is still to be studied how does the holistic, temporally-evolving and subjective user experience of...
MMR build up. In mobile contexts the use situations vary from safety critical, urgent and demanding tasks to free-form leisure-oriented activities. Hence, it is critical to understand in which situations the user may be offered extra information, and in which situations the user must not be interrupted.

So far the research on mixed reality has mostly focused on development of enabling technologies: various types of displays, techniques using eye-tracking, auditory, haptic and gesture-based interaction, as well as algorithms and tools for modeling virtual objects and mapping them on top of the real world view. Nonetheless, the user experience and acceptance perspective of mixed reality services has been studied very little. Such research has mostly focused on usability issues of individual demonstrators. The user-centered design approach is based on understanding the requirements of the user, context, and tasks, but the needs and expectations of the users have not been studied as a starting point of mixed reality. Furthermore, the application areas of the existing MMR applications have been mostly working environment (e.g. remote controlling systems in process automation or in design of 3D objects). The leisure and everyday mobile contexts have not been studied extensively. Being immensely rich by nature, the mobile context provides a basis for very diverse set of use cases where MMR technologies could be utilized.

The context of our study is the DIEM (Devices and Interoperability EcosysteM) project, which aims at building new kind of smart environments that comprise of ecosystems of digital devices [6]. One of the key development areas of DIEM is MMR. The aim of our study was to understand the initial expectations of potential users of future MMR services: what content there could be, and in which kind of contexts it could be successfully used. Thus the study will help in projecting and assessing the early prospects of MMR application areas.

2. RELATED RESEARCH

We first present a few studies relevant of MMR services and applications, and secondly introduce the theoretical background of user experience (UX).

2.1 Mixed Reality Systems

We present related research on applications and system prototypes that utilize design ideas related to MMR. These systems emphasize characteristics of AR (augmented reality), not AV (augmented virtuality). Many of these applications are some kind of games or guide applications, but there are also other ideas of systems that can be useful in everyday life. Also other relevant concepts, e.g. related to context awareness and sharing information are presented.

Ludford et al. [19] have developed a location-based reminder (LBR) system called PlaceMail. The system runs on a GPS-equipped mobile phone. People use it to create and receive personal task reminders. PlaceMail utilizes the phone’s location-sensing GPS to deliver the message when the user is near the place. As people use LBRs, they generate local place data, like lists of places they go for everyday tasks (or place bookmarks) and reminder messages related to the bookmarked locations.

Gleue and Dühne [8] present the ARCHEOGUIDE (Augmented Reality-based Cultural Heritage On-site GUIDE) project, which provides cultural heritage sites with archeological information. With a small mobile computer and a display unit visitors are able to experience the real site while appreciating visualizations of the virtual reconstructions integrated seamlessly into the natural field of view. The mobile device tracks the user’s position on the site. The ARCHEOGUIDE system is able to compute the current view of the reconstructed objects by determining the viewing direction.

Herbst et al. [13] present a mobile outdoor mixed reality game for exploring the history of a city in the spatial and the temporal dimension. The story of the game called Time Warp is based on the legend of the Heinzelmännchen of Cologne. The legend tells that one day these Heinzelmännchen disappeared and the goal of the game is to bring them back. The game aims to fuse real and virtual elements to create the illusion that users are present in the City of Cologne during different time periods.

Flintham et al. [7] describes two mobile games in which online participants collaborated with mobile participants on the city streets. The first one, Can You see Me Now? (CYSMN), was designed to be a fast-paced game in which up to twenty online players were chased across a map of the city, by three runners who were moving through the actual city streets. The main goal of CYSMN was to engage and excite the online players by giving them a sense of the runners’ experience of the city, and of how their online actions could affect events on the streets. In the second game, bystander, a local player takes a journey through the city on the trail of a mysterious person whose name and picture they have quickly been shown. An online performer collaborates as a partner with them and guides them in the search. Between them the two participants travel through the city streets at the same time and across an online map in search of the mysterious target person.

Brown et al. [5] present the co-visiting system which allows three people to visit the Interpretation Centre simultaneously, one physically and two digitally. The physical visitor is in the Interpretation Centre itself with special mobile equipments including location system. The virtual reality visitor uses 3D display with avatars representing the other visitors. The web visitor for one uses a standard web browser displaying several Java applets, one of which is a variant of the physical visitor’s map. The idea is to support looking at exhibits as a group of physical visitors, virtual reality avatar visitors and web visitors. These three kinds of visitors share an exhibition space represented via different user interfaces.

2.2 Theoretical Background of User Experience

User experience (UX) is often understood to cover more or less all the aspects that affect or result from end-users’ interaction with a technological product or service. Hassenzahl & Tractinsky [10] define UX as “a consequence of a user’s internal state (e.g. predispositions, expectations, needs, motivation, mood), the characteristics of the designed system (e.g. complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g. organizational/social setting, meaningfulness of the activity, voluntariness of use, etc.).” Furthermore, a definition by Kankainen [15] describes the temporally evolving nature of user experience: “[…] result of a motivated action in a certain context. User’s previous experiences and expectations influence the present experience; this present experience leads to more experiences and modified expectations". Hassenzahl [11] describes user experience to further involve aspects such
3. OUR USER STUDY

This section further specifies the goals of the study, and presents how we applied focus groups as a research method, as well as the background of participants and what kind of scenarios were used as stimuli.

3.1 Study Objectives

For developing successful and acceptable mixed reality services, it is vital to understand the potential users’ subjective needs with regards to that kind of services, as well as the expectations towards user experience of them. We set our focus on location-based mobile augmented reality information and services. We aimed at 1) identifying and innovating potential use cases for location-based MMR services, 2) finding out what kind of AR information users would value and need, and 3) inquiring the users’ needs and expectations (e.g. potential benefits and drawbacks) for MMR services. Hence, the study setting was twofold: evaluating existing (technology-driven) concepts, and identifying needs for new ones. As this was our initial study to deal with user expectations of MMR services, the research was highly explorative and by nature.

3.2 Study Methodology

There are many definitions of a focus group in the literature, but aspects like organized discussion [16,17], collective activity [22], social event [9] and interaction describe the elements that focus groups have as a form of social research in the HCI field. We chose focus group as our research method as it is excellent for the generation and evaluation of early ideas and facilitating rich discussion. This was a suitable approach as the holistic picture of MMR requires clarification and diverse aspects have to be considered from the users’ perspective. Furthermore, one benefit of focus groups in studying early user expectations is their flexibility to adjust topics between sessions.

3.2.1 Participants

We conducted five focus group sessions with different types of user groups: 1) active travelers or tourists, 2) senior high school students, 3) technology oriented people, 4) wellness-oriented people, and 5) people with ecologically sustainable values. Most participants represented early adopters, as they were required to be at least somewhat interested in new technical products, and thus be potential first users for the MMR services. Incorporating various user groups in the study was intended to bring diversity in the user expectations and ideas. With such a small amount of users and representative groups we did not aim at drawing any conclusions of the differences between certain user groups. Participated users ages varied from 18 to 59, and 13 of the participants were male and 10 female.

Table 1: Background questions about participants’ technical orientation and communication habits (1 "I strongly disagree" - 5 "I strongly agree") (N=23)

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>St. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find technology useful in my everyday life.</td>
<td>4.4</td>
<td>0.7</td>
</tr>
<tr>
<td>I am usually one of the firsts among my friends to get new technology</td>
<td>2.7</td>
<td>1.0</td>
</tr>
<tr>
<td>I like to help my friends and relatives to use technical devices</td>
<td>3.9</td>
<td>1.2</td>
</tr>
<tr>
<td>I like to edit information in Wikipedia or similar.</td>
<td>2.1</td>
<td>1.4</td>
</tr>
<tr>
<td>I like to share information about me for example in Facebook or Irc-gallery</td>
<td>3.3</td>
<td>1.3</td>
</tr>
<tr>
<td>I would find it useful that my friends knew my location and what I’m doing</td>
<td>2.7</td>
<td>1.2</td>
</tr>
<tr>
<td>I’m worried about my personal information spreading in the web and getting in the wrong hands</td>
<td>3.2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

3.2.2 Focus Group Setup

Each focus group session had two parts. First, a rather free-form discussion about potential use cases was initiated with a general introduction to the theme of augmented reality in mobile domain. Next, discussion continued around certain predetermined scenarios that involved various potential MMR use cases. These were presented as textual narratives enriched with visual illustrations. Finally, to gather more structured data for consolidating the explorative and subjective discussion data, the participants filled in an expectations survey that consisted of statements about certain assumedly important elements of expectations. The survey was completed in the end of the session. Altogether, the gathered data was qualitative by nature.

Each session lasted 1 - 1.5 hours and had 4-6 participants. All sessions were recorded and the recordings transcribed. The explorative data was analyzed with a thematic analysis approach – objectively and systematically identifying common themes and meanings from the data and further categorizing them at a higher abstraction level [23].

3.2.3 Narrative Scenarios as Stimulus Material

We had prepared two textual scenarios describing potential use cases and contexts for MMR services: 1) a normal day in a familiar urban context, and 2) as a tourist in an unfamiliar context. Both scenarios were 600-700 words in length, and were divided in four sections to be more understandably presented to the participants. Each section was presented sequentially as a text on a paper sheet, and the context of the section was illustrated with the help of a data projector. Focus groups 1 and 4 discussed the tourism scenario and groups 2, 3 and 5 the “normal day” scenario. Figure 1 exemplifies one section of the “normal day” scenario (translated from Finnish), and Figure 2 presents an illustration of one of the sections.
“…Juhani steps into a bus and touches a digital info spot with his phone. This way he pays for his journey and also gets the bus company’s BusNews-bulletin and services provided in that bus. These services include music lists created by other travelers and different kinds of mobile games. Juhani activates an info sticker on the backside of the seat in front of him and this opens the BusNews bulletin contents list on his cell phone screen. The icons and texts on the sticker become downright alive when Juhani browses the information content in the sticker with his cell phone…”

Figure 1: An excerpt of the “Normal day” scenario

Figure 2: An illustration of one section of the Tourism scenario

Table 1 exemplifies various use cases presented in the two scenarios. Due to paper length limitations, not all use cases are listed. The scenarios involved also other than purely MMR-specific aspects, such as context awareness and automatic information retrieval, which made the use cases more credible in practice. The scenarios were used merely as stimulus for discussion. The use cases or scenarios as whole were not directly evaluated in a structured way by the participants. Therefore, also no comparisons were made.

Table 2 Examples of use cases that especially bring out MMR aspects in the two scenarios

<table>
<thead>
<tr>
<th>“Normal day” - scenario</th>
<th>Tourism scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing the mobile device to the digital info screen and studying other bus options.</td>
<td>User could browse information signs, e.g. history of attractions and info shared by other visitors.</td>
</tr>
<tr>
<td>Activating an info sticker on the backside of the seat in front of him and this opens the BusNews bulletin on his cell screen.</td>
<td>Getting additional information about interesting targets just by pointing the camera viewfinder on them.</td>
</tr>
<tr>
<td>Pointing the mobile to the interactive wall of his office and looking at his calendar.</td>
<td>A virtual tour guide recognizing photo objects and suggests shooting from a different angle.</td>
</tr>
<tr>
<td>Scanning medication products to the mobile device display. The device compares the medicines and gives tips.</td>
<td>Downloading the menu of the restaurant from an information sign and seeing highlights on the specialties of the place.</td>
</tr>
<tr>
<td>Activating movie posters with a mobile device to see virtual movie trailers.</td>
<td>Projecting pictures of how a historical place has looked for example 10,000 years ago.</td>
</tr>
<tr>
<td>The mobile device notifies about a virtual graffiti message left by a friend at a wall of a near-by house.</td>
<td>Afterwards seeing statistics on spent calories and the ecological footprint.</td>
</tr>
<tr>
<td>User draws a virtual graffiti by drawing in the air with his mobile</td>
<td>Setting the mobile device to an adventure mode, in which it automatically notifies about the places user has labeled beforehand.</td>
</tr>
</tbody>
</table>

4. RESULTS

First, we report the results of the focus group discussion that followed the MMR introduction and scenarios, and second the results of the summarizing expectations questionnaire.

4.1 Focus Group Discussion Results

In general, participants found MMR to be an interesting and versatile approach providing new ways of interacting with the information in the near-by environment. MMR services were seen to have the ability to provide richer, more relevant and even surprising information about everyday environments.

Furthermore, MMR information that would not be otherwise acquired would be useful especially in unfamiliar contexts (e.g. while travelling). Overall, information for practical benefit was more desired than purely fun and leisure related information. The discussion focused more or less on augmenting the real world with visual information.

The most interesting MMR information with regard to everyday life was seen to be information concerning weather forecasts, public transportation (e.g schedules and routes of various transportation methods) and location-specific information of services (e.g suitable restaurants within radius of 500 meters). Receiving augmented information automatically for example about nearby attractions would be useful not only for tourist but for locals too. Also real-time locations of various objects as augmented information was considered very intriguing, e.g. finding out when the next bus is coming and where the bus is at the moment. Furthermore, the aspect of social guidance was seen salient in future MMR service. The services could be used for pointing out like-minded people or members of one’s communities in the surroundings and inform about the information they recommend. This aspect of social awareness and recommendations came up in the discussion regarding both everyday and unfamiliar contexts.

“[…] I could just quickly browse what services there are within a few blocks” – Wellness oriented focus group

Regarding unfamiliar contexts and situations the participants considered that MMR services could help and support in cultural issues (e.g translating short text or providing information about unfamiliar technical devices). Also, participants brought up the idea that they could acquire information regarding their own interests and tagged locations, such as attractions and history of the environment. However, they did not want to acquire too much information about the traveling resort before actually travelling. They saw that they might lose the joy of finding and exploring, and thus the main purpose of the vacation would be disturbed. Instead, the user could select certain targets and objects as points of interest that would be explored when in situ. Using MMR services in the nature was also brought up. The service could show where people have walked and provide navigational cues, extra information about certain sights and plants. In time, MMR services could replace the current information signboards.

As mentioned, the ideas for augmented information were mostly visual by nature. One participant’s idea was that MMR could serve as a tool in creating and visualizing 3D models on top of the real world information. Furthermore, the participants
envisioned use cases for fitting clothes virtually with augmented garments. This was considered useful especially for physically challenged people. MMR could also serve as a tool for self-expression: augmenting one’s appearance with virtual hairstyles, makeup, or other adornment. Also, the idea of virtual house decoration and furnishing received much support (e.g. choosing colors or placing furniture in one’s apartment). Finally, most users expected the services to be based on maps (both indoors and outdoors), as the interaction with digital maps has become so prevailing in current mobile services.

4.1.1 Personalization and Information Relevance
Regarding user expectations, one of the key findings was the prominent need for personalizing the services. With this we not only mean personalizing the user interface but also personalizing the service features to be able to offer more relevant and meaningful information and services for the user. The physical devices did not have a big role in the discussion of personalization: the appearance of the device and user interface was not emphasized. Instead, the information content and interaction with it were considered more essential.

“When starting to use any device, no matter whose it is, it would become personalized easily with your own information” – Technology oriented focus group

Personalization was seen as a tool to help finding interesting and relevant services and people and automatically receiving information that one would not have been actively searching for. The discussion repeatedly emphasized the importance of being able to limit the amount and type of information that is acquired with the means of MMR. If personalization is not possible, information flood, dangerous situations, or frustration of use might take place. Especially in case of advertisements, the need for personalization was seen to become even greater.

The relevance of the information was found to be highly dependent on the situation and tasks the user is pursuing. For example, during spare time and in unfamiliar environments one might like to receive lots of various types of information even automatically, whereas in repetitive situations or in hurry getting extra and irrelevant information would disturb and interrupt important tasks (e.g. commercials popping up automatically as the user goes to a place where s/he often visits). Hence, it was seen important to be able to set personal modes and filters (e.g. “shopping”, “meeting friends”) by which the amount and type of information would be determined. Still, several users pointed out that the user should have the possibility to get all the available data if wanted.

“I’m willing to receive advertisements while in shopping mode” – Ecology oriented focus group

In determining the relevance, also the recommendations from people like oneself were considered useful. The MMR service could be aware of what kind of users and events the user likes and in what kind of communities he/she belongs to, as well as what other like-minded unfamiliar people one considers interesting (e.g. celebrities, people with similar backgrounds as the user). The amount and the modality of presentation of the information provided by the service should follow the preferences of the user.

All in all, the concept of context awareness could be identified from several parts of the discussions. The service was seen to be aware of the user’s momentary needs, so that it could adapt and provide information depending on the user’s current context. However, also the problems related to this (e.g. the complexity of context as a holistic construct) were identified in the discussions. The context awareness could be personified as a personal agent, as one participant suggested, that predicts what the user wants and automatically offers interesting and relevant information. For example, another participant suggested that the service should recommend certain adverts for the user, which she/he might be interested in, based on her/his earlier behavior. The activities the user performs should then update and further specify the model of the user. Participants hoped that the service would learn the user’s types of interest and needs, e.g. based on location information.

4.1.2 Reliability and Sociality of MMR Information
There was rather much discussion about reliability and credibility of information in MMR services. Probably the main reason for this was the fact that the information content was seen possible to be created by anyone – as in Internet. The participants tended to trust the information provided by public and official institutions and well-known vendors more than that created by other users.

In general, it was considered useful that users would be able to create content and metadata (e.g. descriptions and tags) themselves. Other users’ comments especially on restaurants and other specific services were regarded as very useful and relevant information. Yet, users should be able to filter the other users’ comments, so that the user would not get comments from totally strange or dissimilar people. Moreover, all publicly available information was required to be up-to-date to be useful and trustworthy. Otherwise one would not base decisions (e.g. related to purchases) on such information.

“If a something has gone extremely well, of course you want to recommend it to others, and vice versa.” – Travelers’ FG

Active updating was seen to raise the trustworthiness of the information. In addition, comments and feedback created by other service users are interesting and reliable only if there are enough commentators. Also, the comment is more trustable the more the user knows about the commentator. People would trust the comments of MMR services as much they now trust comments on Internet forums, where mostly numeric measures (e.g. amount of positive comments) can be used to determine the trustworthiness of information if the other users are unknown. One single comment would not be necessarily trustable, but for example several negative comments would probably influence decision on buying.

4.1.3 Privacy Concerns: User Status and Location
Besides leaving comments, the participants were willing to share information about their current and future statuses. Users would describe what they are doing and what they are going to do and share the information with other users as well as with the service for it to be more aware of the user’s context. In the latter sense, the future status information was considered more useful. We interpret that the reason for such extrovert needs to be the current micro-blogging culture in Web2.0 services, such as in Facebook and Twitter.

Sharing people’s locations divided opinions, as expected. On one hand this kind of services would increase social awareness, which was seen as positive thing, but on the other hand the participants would want to retain their privacy. Sharing
location data would be especially useful for finding and meeting friends without arranging separate meetings at particular place and time. Another positive viewpoint on sharing location information was feeling of safety of one’s family or other significant people (e.g. parents knowing their children’s locations). Being aware of one’s own location would increase feeling of safety especially in foreign locations.

“It would be nice to see that there are couple of friends near-by and a nice special offer on beer”.
– Wellness oriented focus group.

All in all, most participants were willing to share some limited amount of location information as long as the accuracy of the information is controlled by the user. Participants wanted to share their location only with selected people and for selected time duration. User should be able to choose who can see her/his movements and where she/he appears to be for other users. It was also suggested that location information need not always be specific – in some cases only accuracy level of the city district is enough. Also, the location could be shared anonymously (i.e. not revealing the name of the friend who is nearby) or revealed not before the user is in the vicinity of the other user.

4.1.4 Interaction with MMR Services and Devices

Due to the complexity and variety of mobile contexts, interaction with the MMR devices is a challenging topic. When hands are occupied by another task, traditional mobile interacting with keyboard or touch screen becomes impossible. The user’s attention is largely reserved to coping in the physical environment: for example while waiting for public transportation, people tend to engage only in such multitasking that does not hinder them from noticing their transportation to come. Therefore, also the interaction technique and paradigm depend, amongst other things, on the user’s current cognitive and physical capacity.

Participants brought out that when actively searching for information in new contexts, they would prefer browsing the augmented information smoothly and continuously by using data glasses instead of hand-held devices. On the other hand, when not actively acquiring MMR information or interacting with the devices, the user requires cues of the information affordances in the environment. Participants thought that visual cues are often not enough, but also audible or haptic cues would be needed, especially with regard to the most important information. However, when actively using and interacting with the service, visual cues would be preferred over other modalities. The actual interaction and browsing of the information content were regarded so intensive and mentally loading that the visual modality would be preferred in the interaction after the user has been informed of the existing affordance.

What comes to viewing the augmented environment through a mobile device camera view, users said that it would serve this purpose rather well. In addition to the magic lense paradigm, the view could be utilized as a magnifying tool of 3D modeled information and as a window to alternative points of views (e.g. viewing the same environment as it was in antecedent eras).

Overall, pointing objects with a camera view to receive an overview of additional information was considered as a highly intuitive way to get a holistic picture of the environment and its affordances. However, continuous pointing to and interaction with a certain physical object must not require continuous pointing towards the object. Additionally, participants brought out that it must be challenging to determine which object the user wants to interact with in the camera view. Instead of constantly pointing to an object, the user could, for example, take a photo of the view and continue interacting with that. Furthermore, in tasks requiring high accuracy, pointing could be done with one’s fingers or a glove.

“One shouldn’t have to point with the device in his hand for example ten minutes continuously pressing some button”.
– Technology oriented focus group.

Participants suggested also other means of interaction, such as small movement of wrist, to be considered as ways of interaction as well. Also, certain contexts let people perform actions that are significant only at that specific situation. Hence, awareness of the context could be used in determining the user’s mode and which input techniques are enabled in each context. The most futuristic discussions envisioned the device to be able to read input information from the user’s eye movement, or finally read it directly from the mind.

One of the most salient requirements was found to be the need to tag and bookmark the browsed information. This would both increase relevance of the service and make it easier to find and utilize the information again later on. Furthermore, the augmented information does not necessarily need to be virtual information but augmentation could also be used in highlighting the most relevant and critical things in the physical environment (e.g. approaching familiar people or dangers in the environment). One participant mentioned also that the augmentation could be hiding unwanted information with augmented graphical effects. Hence, MMR services could help the user to both observe the most important parts and hide the irritating or unnecessary of both the digital and real-world environment.

One of the most useful potential features of MMR services was seen to be the ability to truly create joint services: one would be able to interact with the augmented information and use other information services via them. For example, the scenario example where the user directly selects and buys a movie ticket from an MMR advertisement was much appreciated.

4.2 Expectations Questionnaire Results

Here, we briefly present the results of the expectations questionnaires. Overall, the results based on focus group discussion supported and consolidated the results of the expectations questionnaire. The idea of mobile services with augmented reality or virtuality elements was regarded as intriguing, but at the same time the participants had doubts about the interaction with services, as well as privacy and information validity issues. MMR features were seen to bring added value, social aspects and liveliness to mobile services and increase one’s understanding of the surroundings. The questions and descriptive statistics are presented in Table 3.

Table 3: Expectation questionnaire concerning MMR services and devices (1: “I strongly disagree” – 5: “I strongly agree”), N=23 (translated from Finnish).

<table>
<thead>
<tr>
<th>Questions</th>
<th>Mean</th>
<th>St. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe that mixing reality and virtual reality in mobile services...</td>
<td>4.4</td>
<td>0.6</td>
</tr>
<tr>
<td>... would bring added value to mobile services.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. DISCUSSION

5.1 Methodological Discussion

Focus groups offer a rich setting for innovation as the input and comments from other people can instantly create new thinking among the participants. However, because of its highly social nature a focus group session has some deficiencies when the aim is to elicit users’ personal opinions and expectations. Considering issues of which the participants might not have a strong insight or opinion in advance, the discussion easily becomes directed towards a general consensus. Thus, individual opinions and needs that differ from the majority might not be disclosed at all. Regarding this study, it is challenging to conclude whether this affected our setup and results or not.

In addition, it might be challenging for the participants to communicate or even identify one’s needs and expectations of such a futuristic topic. With such immature technology and little concrete solutions provided, it was challenging for the participants to picture the actual interaction and, for example, affordance perception issues that are often present when considering mixed reality environments. To minimize this effect of bewilderment from a futuristic technology we kept the contexts, tasks and users in the scenarios as present-day as possible, and only the technology and interaction with it were envisioned. Still, retrospectively thinking, we see that the sessions would have benefited from more concrete, visually described and detailed examples as stimulus materials.

Overall, with such an abstract and conversational research approach to a futuristic technology, the results are not strictly MMR specific – part of the results and ideas could be applied to almost any mobile and context-aware technologies. With such approach we could not investigate users’ thoughts regarding, for example, detailed interaction with the future MMR services operational, for example, how other interaction modalities than the visual modality could be utilized. We see that the visually focused stimulus material and use cases affected the discussion so that no ideas were presented regarding, for example, auditory augmentation of the real world.

Because of the various backgrounds of the participants there was rather big diversity in participants’ technical knowledge. Based on our experiences of various groups, we regard that with such a study setting it required the participants to be somewhat technologically oriented in order to understand the concept of mixed reality and to be able to innovate around it.

5.2 Design Implications

All in all, the focus group sessions provided us the “first contact” with users in regard to MMR service requirements. The understanding from this study serves as a basis in designing the features of early service concepts and prototypes, as well as the user experience provided by them. We received an extensive amount of expectations and design ideas, for example, with regard to relevance and personalization. The results related to information sharing and privacy complement our earlier studies (see e.g. [18,21]). Most of the ideas were something to ease the everyday life, like location information and interpreting different languages in different surroundings. Next, based on the results we propose few implications for designing MMR services and discuss the validity and reliability of the results.

In regard to determining the relevance of information, the service could utilize a personal agent, predicting what the user wants and automatically offering interesting and relevant information. This agent could improve and update the model of user while s/he is using the services. The user should be able to add some kinds of bookmarks and notes to the browsed MMR information. This would serve as a feedback tool for being able to further specify the relevance more specifically. Also, the recommendations from people like oneself were considered useful in determining the relevance. Therefore, the service should leverage other users’ recommendations and other knowledge of the users’ current social environment and the communities they belong to. Relevance also determines the amount of information provided in various phases of the use of the service. For example, in unfamiliar contexts the services should not provide too much information in advance so that one loses the experience of adventuring and exploring.

To support users’ trust for the service and the reliability of its information content, the information should always be up-to-date, and one should see when and by whom the information has been modified. The reliability of the provided information can be an issue if the data is created by other users. For example in pharmacy users might want to get personal service from real personnel instead of trusting the augmented information.

The participants regarded augmentation of the real world not only as putting objects on top of the real world view but also as a tool to utilize the information in a more flexible way. The camera view of the device could also be used as a magnifying glass or seeing overviews of an area in the real world. Although the general opinion was that MMR services should not hide or distort the information from the real world, also contradictory use cases were discussed. The users might benefit from information diminishing instead of augmentation in situations where the real-world information is something that people might not want to see or hear (e.g. unethical issues, advertisements, content with adult only elements). One participants’ solution for this was to hide information in the real world by augmenting blur effects on top of the real world view.

All in all, the presented user expectations are based on a limited number of use cases and types of interaction and thus, the results should not be generalized to represent entire user...
segments. Still, they provide important information for identifying the potential in the UX of MMR services and what are the most salient elements that affect how the UX builds up. The first expectations can provide a basis and starting point for successful development of MMR technologies with good user experience.

6. CONCLUSIONS AND FUTURE RESEARCH
As the main contribution of the paper we present new insight regarding users’ expectations for mobile mixed reality services. We were able to elicit general level requirements and potential users’ needs related to information content, type of interaction and general user experience issues in various MMR environments. We found out that the relevance and reliability of information content are central issues in determining how disruptive or fluent the interactions with MMR services are considered. Relevance affects the overall UX by influencing the sense of utility of the service, as well as how entertaining or stimulating they are for each user. It is based on several contextual aspects: the user’s internal state, general-level user needs and the social environment the user acts in. The concept of personalization (e.g. user-set preferences) was also discussed largely as it was seen as a solution to determine what information might interest the user.

Reliability of information was a momentous aspect in both utility and leisure specific use cases. However, regarding public information, the users tend to trust information created by trustworthy authorities, whereas regarding leisure and product information, the users mostly relied on comments and opinions of social network and other people similar as oneself. Furthermore, privacy issues, intuitive interaction, experiencing the real world itself, and the social nature of MMR services were also seen as important elements in MMR user experience.

Despite the challenging nature of studying expectations of non-existing services and applications, we regard this study to be an important move towards aspiring to understand the requirements for user experience when starting to develop MMR applications. The results serve as a basis for further exploring of the various factors that will affect the felt user experience of the technology prototypes and pilot services.

In future research, we will continue gathering requirements and expectations in real-context settings to gain more innovative and rich user data and use cases. The laboratory-like context in this study was not regarded to provide enough of stimulus for the users. Future research will also further specify issues such as personalization, filtering information, context awareness and proactive activity of the services. The study also pointed out a need for further research on map-based interaction and navigation in the user interface. Finally, the future target groups could be more limited to get more in-depth information regarding certain use cases or environments. We assume that the needs and expectations of users who do not represent “innovators” or “early adopters” would be beneficial to study, e.g. with more ethnographical research approaches.

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8. REFERENCES


