Designing for User Experience: What to Expect from Mobile 3D TV and Video?

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ABSTRACT
A long process has been undertaken to develop the technology of 3D video for consumer products, but studies to determine the needs and expectations of actual users have been disregarded. The object of this study is to examine users' needs, expectations and requirements for mobile 3D television and video. We conducted three user studies applying triangulation methodology of the extensive survey, focus groups and probe studies to identify the requirements. The results are presented in the form of guidelines which highlight the characteristics of users, the system and service required including what content is interesting and the context in which it will be used. Both academia and industry can benefit from knowledge of these requirements when designing the further studies and development work concerning the user experience of 3D television and video.

Categories and Subject Descriptors
H.1.2 **[User/Machine Systems]**: *Human information processing.*

General Terms
Experimentation, Human Factors

Keywords
Mobile 3D TV, User Experience, 3D TV, Mobile TV, Methods, User Requirements

1. INTRODUCTION
To provide a seamless and attractive user experience of novel mobile services requires an understanding of the user's needs. It also requires excellent co-operation between the various players in the field to fulfill these desires. For example, a mobile value chain includes the content owner, the producer and provider who together with the service provider deliver the content to the user. The device manufacturer plays a key role by providing the user interface, including the output devices for the end user to experience the content. In the current phase of 3D or even mobile 3D, there is a lot of work in progress on the different technological parts of the chain. There is a high level of interest in 3D content capturing, transmission and different display technologies in both academia and industry. However, there are not yet any success stories with 3D consumer products as the technology is still maturing. The only way to enjoy is 3D is in the cinema. Except in this respect, the expectations of users and consumers have been overlooked.

No previous work has been done to examine users' needs and expectations for mobile 3D television or video. The published literature is either limited to conventional 2D television or video on mobile devices, or 3D has been studied for static cinema or home environments. The recent studies of mobile video have gone through the chain from users' expectations to the reported field studies resulting in a good understanding of user motivation and the need for particular content as well as usage context and usage patterns. In contrast, the user studies of 3D have mainly paid attention to examining the negative aspects of 3D viewing in terms of viewing discomfort [14][15]. Less attention has been paid to users' desires and the positive aspects of 3D. Freeman's study [10] is the only one examining user's expectations of 3D more broadly. This paper takes the first steps in filling the gap in relation to mobile 3D television or video. Our study helps both academia and industry in developing their ideas on portable 3D systems based on users' needs.

This paper examines users' needs, expectations and requirements for mobile 3D television and video. We restrict our presentation to the user and leave discussion of developing technologies to be considered elsewhere. We present a review of user experience and the methods used to determine it, together with clarification of the main concepts of the paper in Section 2. Section 3 presents an overview of previous work concerning user experience on the topics of mobile and 3D video and television. Section 4 presents three user requirement studies using the methodological triangulation of survey, focus groups and a probe study in two European countries. The results of each of these studies are presented in this section as well as a summary of user requirements in the form of a design guideline. Finally, conclusions are given in Section 5 of the study.

2. USER EXPERIENCE
It is not an easy task to define user-experience. Currently there is no agreed and unique definition of UX among researchers in the field of human-computer-interaction, but there is instead a variety of different meanings associated with it [9]. However, there is a conceptual shift in progress aimed at gaining something more than just good usability, broadening the focus from a highly cognitive and task oriented concept of usability [20] in the direction of emotional and hedonistic aspects, and shifting from negative to

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positive experiences. For the moment, we rely on Hassenzahl and Tractinsky 's [17] definition:

UX is about technology that fulfils more than just instrumental needs in a way that acknowledges its use as a subjective, situated, complex and dynamic encounter. UX is a consequence of a user's internal state --, characteristics of designed system -- and the context -- within the interaction occurs.

The definition was adapted by Roto [39], who later presented a definition for UX, and developed an extensive model for UX in mobile browsing. The UX model presents UX factors and systematic definitions for each of them offering a vocabulary for the field. We have applied this categorization of factors to our work, assuming that mobile browsing has the same characteristics as mobile 3D television at an abstract level. The main factors of UX are *user*, *system* and *context*:

User is defined as a person controlling or manipulating the system and she/he can be described as having the characteristics of needs, motivations, experiences, expectations, mental state and resources [39].

System is defined as the system required for the product under examination to work or to be useful [39]. From the user's viewpoint the mobile system can be a device, browser or player, connection and site or content (adapted from [39]). We use the term *content* to refer any type of moving image or video. The concept of service including, e.g. commercial and a service model, is often overlapping with the term system from the user's point of you. In this paper, we treat service features as part of the definition of system [e.g. [26][31]].

Context represents the circumstances under which the activity (mobile browsing) takes place [39]. Physical, temporal, social and task factors are the essential components of the context. *Physical context* includes the apparent features of situation or physically sensed circumstances including the location [2][39]. *Temporal context* covers the time available for completing the task [39]. The actions in the temporal dimension, vary and can be classified as hurried, normal or waiting [44]. *Social context* describes the other people present, their characteristics, their apparent roles, and interpersonal interactions [2]. It can also describe other people's influence on the user and the user's social contribution goals [39]. *Task context* describes multitasking and possible interruptions that are related to the execution of the task [18][39], e.g. mobile television viewing. It is also worth emphasizing that in the mobile context, physical and social environments are heterogeneous and may change during a usage session, e.g. from individual use to a group situation, from goals to unplanned actions, or from fast to waiting [44].

2.1 Designing for UX

From the definition of UX it is clear that the features of UX are numerous, and so are the features which need to be taken into account when designing the requirements for the new products. In general, human-centered design processes have a cyclical nature including an active user involvement, in order to understand the user's requirements, as well as an iterative design-evaluation process and a multidisciplinary approach [20]. UX is an important factor for the success of products nowadays; focusing on the user has a positive impact on user satisfaction and the quality of the system [30].

User requirements are the starting point in the system development. The requirement elicitation begins with a discussion of needs with users or customers. Users' needs and expectations reflect aspects of their desires and concerns about the system. Conventionally these can be thought of as problems that hinder users in achieving their goals or as opportunities to help users achieve their goals in a particular context [27]. User requirements include any externally visible function, non-functional property or constraint that is required in order to satisfy user needs [27]. From the viewpoint of UX this approach is limited, and therefore at the beginning of the product development, we seek to see requirements more broadly and not only as goal related issues.

There is a large number of different data-collection methods that can be applied to the establishment of user requirements. Hanington [16] has categorized the methods into three groups: traditional, adaptive and innovative. The traditional methods include market research, focus groups, surveys, questionnaires and interviews. These methods gather the opinions of large numbers of people, but their value is in confirming or disproving already known ideas rather than providing new design ideas or perspectives. Adaptive methods include, for example, observational and ethnographical methods [16]. The third group, innovative methods, uses creative or participatory tools such as collages, card sorting, diaries, drama or probes [11] [16][24][32] which aim to seek out novel ideas for the products. These methods are intended to identify the implicit needs and desires of users [16]. Triangulation of different methods, from traditional to creative, is needed to identify the requirements for the different aspects of UX and to gather ideas for the earliest phase of a development project.

3. UX OF 3D TV AND MOBILE TV

User-experience factors have been studied in both 3D television and mobile television. User requirements are relatively well-studied for mobile TV and video compared to 3D television. Currently there are results are available for mobile TV field trials in several countries [3][5][8][34][41] as well as results of prospective focus groups [25] and online surveys [3]. There is only one focus group study [10] available concerning 3D TV and no field studies are available which describe the actual behavior. Other 3D studies focus on psychoperceptual experimental research of visual quality factors [14][37]. This section reviews UX factors of users, system sand services and context in these studies.

3.1 Users

The literature of mobile TV and 3D offers different insights into the users and usage motivations. Based on a mobile TV field trial, Carlsson and Walden [3] describe a typical user as being a well-educated male aged between 23 and 35 with a yearly income of €20,001-30,000. The main motivations for usage are killing time while waiting or staying up-to-date with daily news while on the move [5][29]. Cui et al. [5] lists the novelty of the system and the desire to belong to the group of first users as motivating factors. Owning and sharing of content is also valued by the users [34].

Studies of mobile 3DTV reveal another aspect of the user. The related literature describes a repertoire of aspects for creating an additional entertaining experience with 3D. Presence as the feeling of being there, engagement, naturalness, enhanced realism, and salience all describe the 3D experience and motivate users to

watch 3D content[10][13][37][40]. The negative aspect of the 3D experience is physical discomfort or simulator sickness. The reasons for simulator sicknesses are not fully understood, for example Häkkinen et al. [13] have enumerated a variety of different kinds of eye-related symptoms. This is a drawback for 3D and it is known that the user's enthusiasm for new technology, the learning benefits of viewing 3D and excitement about 3D content decreases significantly with the increase in such symptoms [14][15].

3.2 System and services

Content - Mobile TV studies identify suitable genres and content for the systems. News, music, sport and live broadcasts are among the most interesting genres [3][8][25][41]. However, conventional TV content is not enough. User-created content is seen as a driver for the mobile TV services [34][41]. Because of frequent short time viewing on the move, users expect summaries of existing programs, short clips, or news flashes as well as indexed content to allow easy skipping of irrelevant content [8][41][42].

Related studies of 3D TV give overall advice for attractive genres as well as a description of important content features. Entertainment content, such as action movies, live events, sport and concerts are among the most interesting ones [10]. In contrast to mobile TV, 3D viewers appreciate complex content and long shots, which gives the time to explore the content and its scenic structure [13]. Finally, a good impression of depth is the most important content feature [13][21].

Service - The design of services for mobile TV and 3D TV have not been equally assessed. The existing mobile TV services are examined in greater detail than the 3D TV related services. To access content, users of mobile TV services prefer on-demand services offering a variety of programs to satisfy the needs of different user groups [8][25][42]. Navigation and content search within the service needs to be simple and intuitive. After selecting the content, the service should provide the possibility of pausing the program and then resuming or it should provide looped streams without fixed start and end points [3][42]. Users are willing to pay for the service although, at the same time, they appreciate that TV is sometimes free [8]. They prefer a monthly payment based on a fixed price model (e.g. 10 €/month) or pay-per-view for special services or programs such as live events [3][41].

In contrast to mobile TV, 3D TV is currently found in cinemas and entertainment parks (e.g. www.reald.com, www.imax.com). Important features to promote 3D TV services will be the range of content, compatibility with existing services and a good infrastructure to facilitate access the content [23].

Device - Mobile phones are frequently used for watching TV accelerating their transformation from communication devices to multimedia devices. The users want to have a portable, pocket-sized, mobile TV device even though they criticize small screens and set good audiovisual quality as an important criteria for these devices [34][41]. Standard TV functionality should not suffer from the additional mobile TV functions. It is also necessary to have fluent compatibility with other technical environments at home or at work [41].

Most of the key characteristics of 3D TV systems in the literature are related to factors of viewing comfort. However, these results are conclusions based on practical experience rather than the results of user studies. For example, Kalva et al. [23] suggest that artifact-free and good perception of depth over the whole display is a key requirement for the device [10][21]. The switch between 2D and 3D presentation modes has also been listed as an important feature [10].

3.3 Context

The contexts for usage of 3D and mobile television obviously differ. The viewing contexts for 3D TV are fairly static and homogeneous environments like cinemas. Studies into 3D TV contexts are rare. In contrast, there are several contextual studies about mobile TV use. They offer good insight into how, when and where users access mobile TV systems., The physical, temporal and social contexts for mobile TV will be presented in detail.

Physical context – Mobile TV can be used anywhere [41]. The main listed physical contexts are being-on-the-go, at home and at work [29][35][41]. Watching while commuting is one of the main uses [5][34][35]. At home, users prefer mobile TV to create privacy, to watch content privately or to watch different TV programs while being in the same room with other people [5][34]. At work, mobile TV offers entertainment during breaks or lunch [34][35]. Pupils want to take mobile TV to school [41]. Mobile TV makes television available where normal television is absent or inaccessible [34].

Temporal context – To a large extent, mobile TV viewing is used to fill in time [35][41]. Viewing occurs during macro-breaks since starting the viewing takes time [5]. Typical viewing time for mobile TV is 10-15 minutes [3][41]. During short breaks or hectic activity, users prefer to listen to music or radio [5][34][35].

Social context - Mobile TV is mostly regarded as a single-user system [34]. It is used to minimize solitude, avoid social engagement and create private space [34]. In addition to single viewing, shared watching is also appropriate in certain situations. Mobile TV can form social groups by sharing an experience – watching a group can be almost ritualistic, allowing the sharing of jokes or stories [34]. Shared viewing can also occur passively. Involuntary co-viewing can take place on public transport or in crowded environments [5].

4. USER REQUIREMENT ELICITATION

We applied triangulation methodology on the basis of a survey, focus groups and a probe study for the elicitation of user requirements. Our aim was to target both explicit and implicit requirements when choosing the three different methods [16][30]. All of these studies took a place concurrently during spring 2008.

4.1 Survey

Surveys are commonly used as a method to identify requirements [30]. The role of the questionnaire in the earliest phase of product development is exploratory and is not aimed at confirmation of any particular theory. In the exploratory phase of the design process, surveys can help to identify current practices, needs of and attitudes to the new system ideas [35]. Their weakness, however, is their limited ability to generate new ideas [16].

4.1.1 Research method

Data-collection - The literature review of mobile and 3D television and videos was used as a base to design the user requirement questionnaire for mobile 3D television and video. It

contained four parts: 1) background information, 2) user's motivations for mobile 3D television and video viewing, 3) requirements for content, and system and service functionalities, and 4) context of use.

The data-collection was carried out using an online questionnaire in Finnish and German. Prior to publishing the questionnaire an expert evaluation was undertaken by three external evaluators to improve its content validity. The online questionnaire, advertised in web pages, forums, email lists, was open for three weeks.

Method of analysis - The questionnaire data was measured on a 5-point Likert scale, but in the pre-processing, ordinal data was converted into a nominal form (Kolmogorov-Smirnov $p>.05$). McNemar's test was used in the analysis of the nominal data to test the differences between two categories in the related data [6]. Both language versions of the questionnaire were combined to represent overall view of users' requirements of mobile 3D TV. It should be noted that this research was aimed at the elicitation of user needs. It is neither market research nor cross-cultural research since the samples were not representative of the whole population of either country.

4.1.2 Results

The total number of respondents was 342 (198 Finnish, 144 German) and a description of the sample is given in Table 1

Table1 Demo/Psychographic description of survey sample

SURVEY SAMPLE: DEMO/PSYCHOGRAPHICS
Age:
<18 (1.8%), 18-25 (37.7%), 26-30 (30.1%), 31-40 (20.5%), >40 (10%)
Gender: Female (26.9%), Male (72.5%)
Occupation:
Unemployed (1.8%), Pensioner (1.5%), Student (47.1%), Employee (45.6%), Executive or Entrepreneur (4.1%)
Technology attitude, DSI [12]:
Innovators (.3%), Early adopters (32.7%), Early mainstream (32.2%), Late mainstream (26%), Laggards (5.6%)
TV consumption (daily): Mean=1.745 h, Std. Dev.=1.355 h
Mobile services (weekly):
≥5 services (30.7%), 1-4 services (61.4%), Not at all (7.9%)
3D viewing experience:
Regularly (3.2%), 2-5 times (30.7%), Once (23.4%), Not at all (42.4%)

4.1.2.1 User

User's motivation - The main motivations for mobile 3D television viewing are to be entertained, to kill time, to obtain information and to relax [over 54%, $p<.05$; Figure 1]. Other highly valued motivations are the chance to experience 3D privately, learning and gaining privacy in public settings (at least 40%).

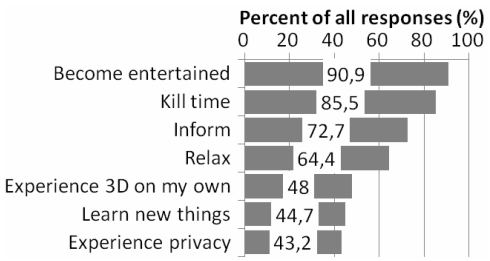

Figure 1 Main motivations for mobile 3D viewing

4.1.2.2 System and Service

Content - Both entertainment and information content are interesting for the mobile 3D TV presentation. Films are the most appropriate content, followed by documentaries, news, animations, music videos and television and weather forecasts [$p<.001$; Figure 2]. Foreign television series, sitcom, sports and current affairs programs are all in the list of the ten most interesting content subjects [$p<.05$]. In addition to conventional television content, 3D presentation is also interesting for other subjects. Tailored or customised content for mobile 3D television and navigation are the most interesting video content types for mobile presentation [$p<.05$; Figure 3]. Film trailers, animations, games, and special presentations, like virtual museum or city guides are also interesting content for 3D video presentations on mobile devices [over 40% of respondents].

Mobile 3D video was also evaluated with respect to messaging functions comparable to the SMS or multimedia messaging. A high level of interest was expressed for storing (65.2%), receiving (62.8%), sending (60.4%) and recording (57.1%) of messages. In contrast, editing (40.8%) the content and sharing it with a wide audience on the internet (39.6%) were less attractive options [$p<.001$].

Service design – The majority of the participants consider that mobile 3D TV should be an on-demand service (70.4%) rather than push type of the service (26%). Most of the participants (60.8%) preferred monthly billing, but pay per view was also highly rated (39.2 %).

Device - The preferred display size and audiovisual presentation modes were the features of the device which were evaluated. A display size of 4-5 inch is seen as the most suitable for viewing 3D television or video on a portable device (33.2%). In addition, the display sizes of 3-4 inch (21.3%), 5-7 inch (18.6%) and larger than 7 inch (21.9%) are also considered as suitable, whereas a display of 2-3 inch (5.1%) is considered to be too small.

The results of different audiovisual presentation modes highlight the need for both single and multimodal options on mobile devices. The results showed a high level of interest in 'audio only' on the move (81%; $p<.001$], audiovisual presentation (68.9%) and a simple shift between these two modes (64.5%). With respect to video, visual presentation should be readily switchable from 2D to 3D (48.4%). The least interesting option, but still highly rated, is the 'video only' presentation mode (48.4%).

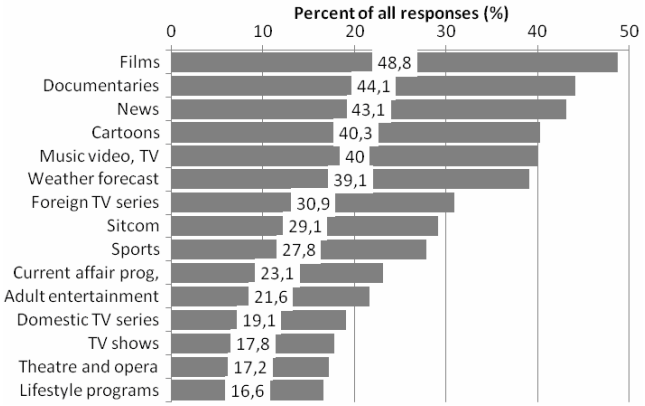

Figure 2 The most interesting television contents for mobile 3D

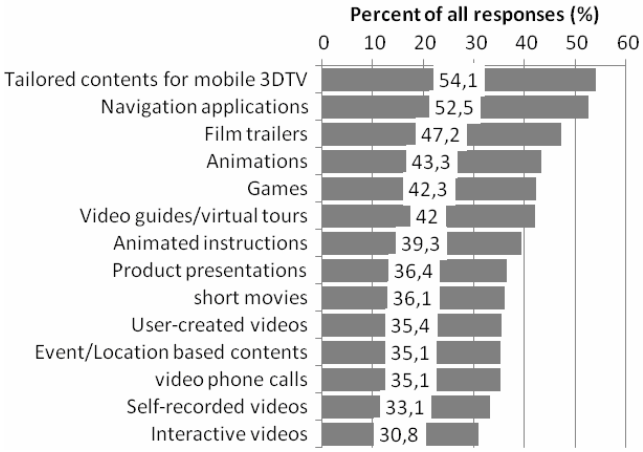

Figure 3 The most interesting video contents for mobile 3D

4.1.2.3 Context

Physical context – Investigation of the physical context of suitable locations for watching mobile 3D TV. The most attractive locations for watching mobile 3D TV are lounges and public transport [p<.001Figure 4]. Over 40 % of respondents also expect to be able to watch mobile 3D TV in hospital, at home, or in busy environments. In addition, watching in a park, car, cafe or at home before going to sleep are all seen as attractive options (over 29% of respondents).

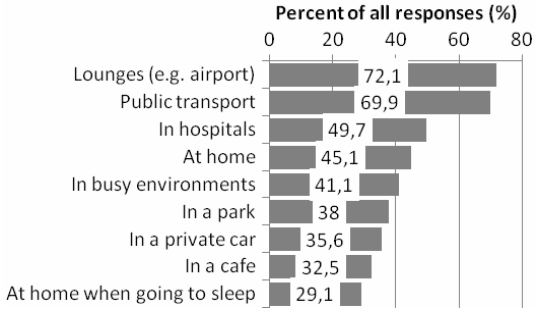

Figure 4 The most interesting physical locations for mobile 3D

Social context – Investigation of the social context covered interest in private and shared viewing. The majority of the participants would watch mobile 3D TV on their own [79.5%; p<.001], but viewing with someone else (34.6%) or in a small group of people (28.9%) were also assessed as possible options.

Temporal context - Temporal context refers to the length of viewing. Using mobile 3D TV during a long journey (87.8%) is the most interesting option, followed by short waiting situations (49.7%) [p<.001]. The other options – watching while commuting (32.9%), during short coffee (29%) or lunch breaks (26.5) or other waiting situations, e.g. in the office (25.6%) – also describe possible usage situations.

The most suitable the length of viewing for mobile 3D TV are from a couple of minutes (59.1%) to 15 minutes [62.8%; p>.05, difference to others p<.01]. Viewing for half an hour (43.3%) was also significantly preferred to longer lasting options (an hour lasting (31.3%) and full film viewing (33.7% p>.05).

Task context - Mobile 3D TV viewing is mainly considered as a primary task in which the user has her/his full attention focused on viewing (36.6%). Parallel tasks of viewing and chatting is the next most interesting option (25.6%). In contrast, viewing as a secondary task, e.g. keeping television as a background sound is a less attractive option for mobile 3D TV (17.3%).

4.2 Focus Group Study

4.2.1 Research Method

Focus groups are used to gather user requirements and investigate the user's thoughts on product concepts or ideas. The strength of focus groups lies in the effects of synergy in a group discussion which can reveal valuable information cheaply and quickly [7][28]. A limitation is that, the individual requirements of users may be lost due to overwhelming group interests. This method has been applied, for example, in eliciting user requirements for mobile TV and 3D TV [10][25].

Participants - Eight focus groups were conducted with a total of 46 participants. These were carried out in Germany (6 groups) and Finland (2 groups). Four target groups of participants were recruited [Table 2]. All participants were classified as either "early adopters" or "early mainstream" according to Domain Specific Innovativeness Scale [12].

Table 2 Target group description of focus group study

DECRIPTION OF FOCUS GROUPS
Group 1: Pupils (1 group, 7 participants)
Age: 16-19
Education: High school
Income: € 30-70 per month
Group 2: Non-technical students (2 groups, 12 participants)
Age: 18-30
Education: Non-technical studies at university
Income: € 100+ surplus per month
Group 3: Technical students (3 group, 15 participants)
Age: 18-30
Education: Technical courses at university
Income: € 100+ surplus per month
Group 4: Employees (2 group, 12 participants)
Age: 25-50
Education: High school or higher degree
Income: € 1500+ surplus per month

Procedure - The procedure was a scenario-based design of focus groups mixing 'explorative' and 'feature prioritization' group types [28].It contained four parts: First, the moderator introduced the goal of the session. Second, the focus was set on television habits and user expectations about 3D TV stimulated by advertisement images of 3D displays. No mobile autostereoscopic device was available for showing a real stimuli. On the other hand, the absence of real stimuli allowed the users to develop their own ideas with no limitations imposed by the state-of-the-art of mobile autostereoscopic displays. The third part was a discussion about mobile devices currently in use. The goal was to establish the idea that "mobile" is not confined to mobile phones. Participants' minds were thus opened to the diversity of mobile devices (e.g. functionality, overall size and display size). After discussing 'mobile' and '3D TV', mobile 3D TV was introduced as a scenario-based discussion. Participants were asked to imagine that they are in a city where mobile 3D TV is already a running system without limitations. Participants then developed their preferred scenarios according to their personal preferences and

expectations. The scenarios were illustrated on a whiteboard. Finally, the scenarios were discussed by the group in relation to devices and service design.

Method of analysis - The qualitative analysis was based on Grounded theory developed from Strauss & Gorbin [43]. Grounded theory is applicable to research areas with little a priori knowledge. It is also suitable when the research aims at understanding the meaning or nature of a person's experiences. The theory or its building blocks are constructed from data with systematic analytic steps. At the beginning, all written material from the focus group was read though to enable open coding. Open coding of all the material was undertaken to identify the concepts and their properties. Because the open coding of data revealed similarities between countries and groups, we applied the same coding framework to the entire analysis. The concepts were organized into categories and grouped under the three main UX factors; user, system and service and context. The total number of categories created and the frequency of mentions of these categories are presented in [Table 4].

4.2.2 Results

4.2.2.1 User

User's motivation - According to the scenarios developed, users expect to use mobile 3D TV either to be entertained or to be informed according to the context. They wish to access content irrespective of location and time, to fill in time or in situations where information is needed instantly. These factors also reflect user motivations. However, users emphasize that mobile 3D TV needs to offer added value compared to existing systems if they are to be motivated to start using it.

"Even if it sounds simple, I wish to have three-dimensional content always available when it makes sense that it is three-dimensional."

Impressions of added value - Panelists expect to have improved realism and naturalness and better emotional identification with the content. The latter will increase the entertainment value of content while the other characteristics will improve information services.

4.2.2.2 System and Service

Content - Scenario development resulted in two main scenarios. In relation to entertainment, users expect TV content such as action movies, sports broadcasts, cultural programs like theatre, and, surprisingly, advertisements. Another very popular entertainment content is 3D games in which a three-dimensional display is expected to create increased fun and excitement. For informational content traditional TV subjects, like news clips or documentaries are attractive. However, the most important scenario was interactive guidance services. It could offer information for tourists in foreign cities, additional information about exhibits in museums, or manuals whenever needed. Other non-TV scenarios were teaching or video-phoning.

"If I am at a bus stop or on the bus I always need to fill in time, then I would play the 3D mobile games that I just invented."

Service design - Service design is expected to offer on-demand facilities. Panelists expect general availability of services but they want to select the content and services very specifically. This on-demand access will be paid by pay-per-use or specific bundles. Data transfer costs must be covered by flat rates. Another option to finance the service is advertisement-based applications.

Device - Devices are expected to fit in the pocket and to have intuitive controls. To combine both of these features, designs need to eliminate physical buttons and have touch screens to control all functions. Screen size of the device should not exceed 5 inch. If larger screens are needed, they can be plugged as an additional feature.

4.2.2.3 Context

Physical context - Physical context of mobile 3D TV is mainly related to indoor and outdoor activities. Typical locations to use the service are public transport, shops, while walking through cities or parks, but also in cafes, stations, museums or waiting rooms. The use of the service at home is not expected.

Social context - Mobile 3D TV is mainly for private viewing. But shared-viewing will be needed when the mobile 3D device is used to entertain oneself and friends by watching movies or while playing games. Interaction with other devices, mainly in gaming situations, is related to the social context.

Temporal context - Mobile 3D TV is appropriate for time-wasting/filling situations. Mobile 3D TV is a gap filler when waiting and in these situations short viewing times are expected. Longer items are preferred during journeys where mobile 3D TV offers distraction and entertainment to offset boredom.

Task context - Mobile 3D TV viewing will take place in single- and multi-task situations. Entertainment viewing represents the typical single task situation. In the multitask cases, mobile 3D services are expected to provide guidance and help in different situations, like moving through unknown locations or museums, or providing help in emergencies.

4.2.2.4 Concerns

The results raised some concerns related to future mobile 3D TV or videos. Firstly, it was thought that highly engrossing content might cause users to loose touch with and take people out of their environment. Secondly, viewing in a public settings may disturb others, involve them involuntary into viewing or threaten the privacy of the owner of the device. The ability of 3D to enhance the emotional experience and providing anonymity in the mobile environment are contradictory features. Finally, the results show that people are concerned that mobile 3D services will just be built on users' fascination with the new experience. They do not want a service that eventually becomes less attractive as the fascination gradually decreases with time so that the advantages over existing systems vanish.

4.3 Probe study

In user-centered design, probe studies with self-documentary tools and projective tasks have been applied in various ways. Probes have been used to discover users' needs, values and feelings for the starting point of design process. Typically, participants are given documentation tools for reflecting and expressing their thoughts about new products and services. Several different types of probes exist such as cultural [11], technology [4], mobile [19] and empathy probes [33]. Self-documenting and projective methods aim to engage and provoke implicit responses from users without observing or asking them directly. This is different from traditional user-centered design methods, such as surveys and focus groups, which have the emphasis in explicit information

gathering. Furthermore, probes provide access to participants' everyday lives and private environment. These are not easily accessible through conventional studies. The spontaneous use of a disposable camera can be highly beneficial to design [32].

4.3.1 Research method

Procedure - This study combined self-documentary tools (diary, disposable camera) and a projective task (collage). We compiled a probe package that contained a disposable camera, a small booklet and material for the collage [Figure 5]. Additionally, written instructions that described participants' task were delivered with the package. Ten participants were sent the package and they returned it after the study period of four weeks. A week after return of a package, a phone interview took a place.

Figure 5 The probe package

Each participant's task was to create a collage to express their expectations and emotions regarding the usage of 3D-television and video on a portable device. We asked participants to take pictures of any situations in which they could imagine watching mobile 3D TV. They wrote a short note about each image in the diary. These notes helped us to interpret the pictures in the analysis stage. In addition, we called for the participants to document their thoughts and feelings in general about mobile 3D TV use to their diary. We advised them to write it at home as well as while on-the-go. When working on the diary and with the camera, participants were encouraged to log their thoughts in a variety of situations and contexts. When creating the collage participants worked reflectively and expressed their thoughts about real and imagined situations.

We were actively in contact with participants to encourage them during the whole period of study. We designed a questionnaire in the form of four e-cards, each consisting of an image and an open question. The cards contained questions about the added value of 3D, shared viewing, motivation and value as well as suitable situations for watching mobile 3D TV. The e-cards were sent to the participants in the second and third week of the study and the participants wrote their responses in their diary. Furthermore, they could include ideas about the questions in their collage and pictures.

Participants – The participants chosen had a mixture of backgrounds and they represented different age, gender and occupational groups [Table 3]. All participants were Germans. Nine of the ten participants finished their work for the study. Participants were each paid 50 Euros.

Table 3 Participant description of the probe study

Age	Gender	Occupation
18	Male	Grammar school pupil
18	Female	Grammar school pupil
19	Male	Student of computer science
21	Female	Trainee as occupational therapist
25	Male	Management assistant in IT-systems
26	Female	Student of biochemistry
26	Female	Graduate social pedagogue
29	Male	Graduate engineer
44	Female	Journalist

Method of analysis - The qualitative analysis followed the principles of Grounded theory [cf. 4.2.1] and it was applied to all the collected material (collage [Figure 6], pictures, notes in the diary). After open coding, all codes were checked by two researchers. To supplement the understanding gathered from the material and to avoid possible misinterpretation a semi-structured phone-interview (~20 min) was conducted. The total number of categories and frequencies are presented in Table 4.

Table 4 Categories and their frequencies of the focus groups and probe studies

Categories	Focus groups		Probe study	
	No.	Freq.	No.	Freq.
User	29	179	23	65
System	59	283	29	106
Context	15	64	41	195

4.3.2 Results

4.3.2.1 User

Motivation - The participants expect to watch 3D TV on a portable device to be entertained, to get information, to relax, to avoid loneliness, as a distraction or to fill in time The advantage of mobile 3D TV is to avoid missing a program while being on move. People would also buy mobile 3D TV to have a piece of the newest technology and to be trendy. Mobile 3D TV was described as an alternative to and as an addition to watching normal TV and the cinema.

Impressions of added value - Participants would like to experience more realistic and authentic scenes through the three-dimensionality:

"Three-dimensionality creates more reality and with it more suspense, more emotion and more detailed shots of my favorite actor."

Several comments related to the feeling of being inside, being close to or being a part of the program viewed:

"... the feeling to be at the place of the event that I'm watching."

One participant mentioned a spatial experience and a feeling of being involved in the depth of the space. Through 3D educational programs are expected to be easier to understand and more fascinating. Participants expected to have different points of view and to experience the content in a new way.

Target groups - The participants did not see only themselves as users of mobile 3D TV and they also named other possible users. Primarily, teenagers were mentioned and the collages mainly had pictures of young people. Moreover, children, housewives and husbands were mentioned as target groups for mobile 3D TV.

Figure 6 Participant's collage

4.3.2.2 System and service

Contents - TV content for entertainment, information and for education purposes would be watched in 3D. News, sport, series, movies, documentaries, music programs and videos, cooking shows, cartoon and animation movies were mentioned. Furthermore, children's programs as well as adult entertainment were described as attractive content. The length of the content was mainly disregarded in the study but two participants brought up a need for short clips and summaries (of sport events) for mobile 3D TV. Receiving videos on-demand seems to be an important service.

In addition to TV content, other content and services were reported as interesting for 3D presentation. The participants mentioned navigation applications (e.g. interactive city maps, building plans), games, video phone calls, advertisements, and product presentations. Furthermore, video chat, Second Life, user-created videos from YouTube, and photography would be an exciting experience in 3D. In addition to viewing content, people would like to record, for example, events, concerts or short clips from holiday to send to friends and family.

Device - A desirable mobile 3D device would remain the same as the current devices with relatively wide displays and limited number of buttons (e.g. mobile phone, PDA, and iPod to iPhone). Small displays would be sufficient for short time viewing whereas a wider display is needed for longer viewing. Headphones are an important part of the equipment to watch TV and avoid disturbing other people.

4.3.2.3 Context

Physical context – The physical context varied from outdoor to indoor and from private to public environments. Mobile 3D TV would be viewed when traveling by public transport (e.g. train, tram, bus, metro), by car, plane, or on boat journeys. Based on the "probe" material the meaning of home environment was highlighted. In the home context, watching in the kitchen while cooking, or in bed before going to sleep or on waking, in the bath tub, in the toilet, on the balcony or terrace and on the sofa were all represented. Furthermore, mobile 3D TV would be viewed both while being on the move, at a railway station or bus stop, and at school, university or work. Outdoor viewing would be attractive in a park, in the garden, at the beach, while camping or during a hiking trip. Other contexts included a cafe, while queuing in a supermarket or in public offices, in the waiting room of a doctor's surgery and as a hospital patient.

Social context - Mobile 3D TV is primarily interesting for individual viewing. However, watching with friends using one device is also an attractive idea. Co-viewing could take a place in a park, at a picnic or at the beach, while traveling with and waiting for public transportation or while talking in a foyer.

Temporal context – Mobile 3D TV viewing would fit easily into waiting situations and to bridge (unexpected) time gaps (e.g. at a doctor, hairdresser, while queuing or as a co-driver in a car). Watching could happen during short or long journeys, journeys to work/school and while waiting for transport. Some participants claimed to watch while waiting for service in a cafe, during the breaks at school or work. Participants would watch at home, Especially in the morning and in the evening..

Task context - In addition to focusing fully on watching mobile 3D TV, viewing could happen while engaged in another activity (e.g. jogging, cooking, housework or eating).

4.3.2.4 Concerns

The price, appropriateness and changes of media importance raised concerns about mobile 3D TV. The high price of the device was listed. One participant mentioned that watching news in 2D rather than 3D would be sufficient for her. The possibility of viewing 3D TV anytime and anywhere may decrease the importance of other media, like books and newspapers in daily life.

4.4 Summary of requirements

To summarize the user requirements, we provide initial design guidelines for UX design of mobile 3D TV and video. They can be used by groups such as researchers, designers, developers, content producers and providers and marketing people.

User - Mobile 3D needs to provide the following:

- Fulfill entertainment and information needs. Users also want to relax, to spend time, and to learn by using mobile 3D services.
- Increased realism and naturalness and evoke an emotional relation and a greater feeling than existing systems of being inside.

System & Service - Mobile 3D system needs to offer **the following:**

- TV content (e.g. news, series, sport, documentaries) as well as other video contents (e.g. games, tailored 3D content, interactive guidance, navigation, product presentation).
- Both on-demand and push services, and both pay-per-view and monthly payment options.
- A device with a display size of 3 inches or larger and probably 4-5 inches
- Both mono- (audio or visual only) and multimodal (audiovisual) presentation modes and an easy shift between multimodal and visual 2D-3D presentation modes.
- Interactive possibilities including saving, receiving, sending, and recording.

Context - Mobile 3D viewing has the following attributes:

- Takes place in public and private locations and in outdoor and indoor environments, potentially on public transport, or in parks, cars, cafes, waiting rooms or at home.
- Is primarily for private and focused viewing, but there is also a need for shared viewing.
- It is well-suited to waiting situations, during transport trips in coffee or lunch breaks, and for short time viewing from a couple of minutes to 15 minutes or half an hour.

5. DISCUSSION AND CONCLUSIONS

This study examined user requirements for designing mobile 3D television and video. We conducted three user studies, survey, focus groups and a probe study, to form an initial user's idea of mobile 3D television and video. The results are expressed as user, system and service, and contextual requirements.

The conclusions have similarities to but also differences from the previous user experience studies of mobile or 3D television or videos. The similarities and differences appeared in user, system and service, and context factors of UX. To highlight some of these aspects, the desired television content, entertainment and information, remain the same as in of mobile television studies [3][8][25][41]. Interestingly, films were also attractive for mobile presentation, being consistent with previous studies of 3D [10], but in contrast to the studies of mobile TV. [3][8][25][41]. This might be because of different usage patterns. Film viewing can fit well into a time killing scenario while traveling, but not into relatively short time news viewing. Further work needs to focus on identifying these patterns. Other video content was also thought to benefit more from mobile 3D presentation than conventional TV content. This feature shows a potential, novel application field for 3D TV for personal use. It also reflects the fact that users are adapting increasingly to different types of video presentations in their daily lives (e.g. YouTube, product presentations).

The user requirements presented here give the first overview of mobile 3D television and video requirements. These results can be used as an input for defining functional, non-functional and constraints requirements for the system**.** At the current stage, the results are also beneficial when conducting experiments to evaluate the quality of critical system components, like 3D visual quality factors [22]. The results offer guidance concerning users, content and context selection for these quality optimization experiments.

It is also worth of noting the limitations of the current results and the need for further work. Firstly, the current requirements are incomplete and they only offer initial ideas of the wider aspects of mobile 3D television and video. To understand these requirements in greater depth, further steps are needed. For example, needs of different user groups, impacts of gender, current media consumption habits and experiences should be seen as a part of the requirements. Similarly, the different detailed usage patterns and scenarios need to be identified to understand their contextual aspects. Understanding these factors will help to capture multifaceted UX as subjective, situated, complex and dynamic phenomena at the design phase [9][17]. Secondly, it is known that imagining something which does not yet exist is a difficult task [30], which can result in inaccuracies in the description of requirements. To proceed beyond this limitation, iterative design [20] and early phase prototyping [30] should be used to specify the initial requirements. Thirdly, the examination of the strengths and weaknesses of the triangulation methodology we used to elicit requirements elicitation could be addressed systematically in further work.

To conclude, this study presents user needs, expectations and requirements for personal mobile 3D television and video use. Previous 3D-related studies have disregarded these aspects which motivated our research. We have presented the results of three different user studies as guideline requirements emphasizing the factors of UX-users, the desired system and service, including interesting content, and usage contexts. Further work is needed to examine the UX factors in detail in an iterative process to facilitate a deeper understanding of user requirements.

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