Let me catch this! Experiencing Interactive 3D Cinema through Collecting Content with a Mobile Phone

Jonna Häkkilä[1], Maaret Posti[1], Stefan Schneegass[2], Florian Alt[2,3], Kunter Gultekin[1], Albrecht Schmidt[2]

[1]University of Oulu
CIE
Pentti Kaiteran katu
90014 Oulu, Finland
firstname.lastname@cie.fi

[2]University of Stuttgart
VIS
Pfaffenwaldring 5a
70569 Stuttgart, Germany
firstname.lastname@vis.uni-stuttgart.de

[3]University of Munich
Media Informatics Group
Amalienstraße 17
80333 München, Germany
florian.alt@ifi.lmu.de

ABSTRACT
The entertainment industry is going through a transformation, and technology development is affecting how we can enjoy and interact with the entertainment media content in new ways. In our work, we explore how to enable interaction with content in the context of 3D cinemas by means of a mobile phone. Hence, viewers can use their personal devices to retrieve, for example, information on the artist of the soundtrack currently playing or a discount coupon on the watch the main actor is wearing. We are particularly interested in the user experience of the interactive 3D cinema concept, and how different interactive elements and interaction techniques are perceived. We report on the development of a prototype application utilizing smart phones and on an evaluation in a cinema context with 20 participants. Results emphasize that designing for interactive cinema experiences should drive for holistic and positive user experiences. Interactive content should be tied together with the actual video content, but integrated into contexts where it does not conflict with the immersive experience with the movie.

Author Keywords
Interactive cinema; mobile phone interaction; 3D; user studies; user experience.

ACM Classification Keywords
H.5.m. Information interfaces and presentation: Miscellaneous.

INTRODUCTION
During the past few years, new technologies and services have emerged around the entertainment industry, including the rise of 3D movies and an ever-increasing number of movie-related extra content available online. In the era of the mobile Internet, mobile apps, and social media services, extra

Figure 1: Interactive 3D cinema: We conducted a user study in a real cinema to explore the concept of interactive 3D cinema, focusing on the impact on user experience.

content related to the movie can be searched, accessed, and discussed easily, virtually anywhere. In this paper, we look beyond the conventional experience of watching a movie and explore the concept of interactive 3D cinemas.

Capturing and assessing interaction around TV and cinema content has so far been possible through Twitter, Facebook, or tailored mobile apps [25]. These interactions are particularly valuable for several reasons. On one hand, they could be used to implicitly identify interesting parts of the content, for example, those that trigger most discussion. This may help producers to enhance the story of future episodes or also provide an automatically created summary, for example, of a sports game. On the other hand, this is interesting for merchandising. While the merchandising industry currently mainly targets the after-movie experience through selling products to fan communities, our approach can complement the instant experience and trigger sales already during the movies.

At the same time, with the rise of mobile apps and social media, we see 3D content becoming more popular – both in cinemas and at home. This allows more immersive experiences to be created by having an additional dimension for information placement. Today, this dimension is used to create special effects and, thus, intensify the user's experience.

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The use case for our work is an interactive movie that could be shown in a cinema. In this movie users can collect different items by catching them through mobile phone based interaction techniques. The main focus of our work is on understanding the UX aspects of interactive 3D cinema. Particularly, we chart what kind of user experiences and preferences different interaction and visualization methods provoke. In order to do so, we compare different concepts, namely

- catching interactive elements in a competitive vs. informative condition,
- touch vs. shake gestures on mobile phones, and
- different types of interactivity cues.

The novelty of our work lies in presenting the first study on interactive S3D cinema where users interact with their mobile phones to collect content and in conducting the study in a real cinema. While our study is artificial in that we used customized, short movie clips, we made the experiment as realistic as possible by conducting it in an authentic environment. We assessed our research questions through logging, questionnaires, and interviews.

The contribution of this work is twofold. First, we investigate the requirements for interaction with 3D content, including means to communicate the interactivity of particular screen elements and suitable interaction techniques to retrieve the content. Second, we evaluate the influence on UX. Our work provides information for future researchers and practitioners who want to create interactive cinema experiences. Particularly, we (a) identify preferred input modalities, (b) show design solutions for presenting the interactive content, and (c) report on user perceptions and lessons learnt on the concept of collecting items in an informative and competitive manner.

RELATED WORK

Our work draws from several areas of related work. Particularly we revisit work on experience with new (S3D) media, interactive cinema and TV and interaction with large screens.

Experiencing New (S3D) Media

Along with the fast development in media technologies as well as communication and social media services, the culture of consuming media content and activities around it have changed compared to conventional practices. Mobile devices in the form of smart phones and pads have liberated the access to media content [6], social media services increased the opportunities to immediately share and discuss the experiences [25], and new technologies such as S3D have emerged and are seeking to provide better and more immersive experiences for people [11]. Nakatsu et al. describe that in the age of rapidly developing technologies, we witness the development of new media, characterized by (a) new types of experiences, (b) active instead of passive experiences, and (c) integration of spatial, social, mental, and physical presence [18].

User experience (UX) has gained an increasing amount of attention in HCI and design communities. Although there is hardly a unified definition for UX [15, 16], it is widely agreed that UX goes beyond usability and instrumental aspects [16]. A definition presented in [9] describes UX as "a momentary, primarily evaluative feeling (good-bad) while interacting with a product or service". UX includes both a utilitarian and a hedonic aspect [10], which affect the holistic experience when using a product. Forlizzi and Batterbee have formulated a UX framework around user-product interaction, and distinguish between fluent, cognitive, and expressive interactions [7].

When comparing the UX of a 3D media installation to a conventional 2D presentation, Karukka et al. reported that user perception with 3D is more conspicuous, interesting, and visually attractive, whereas 2D was perceived more serene, basic, and matter-of-fact like [12] . In the context of auto-S3D mobile phones, it has been pointed out that S3D UI design concentrates on impressive visual effects, but utilitarian value for using 3D in the UI is largely missing [27].

Whereas our research focuses on interaction, earlier research has mostly concentrated on the viewing experience. Stereoscopic screens have been found to have benefits in encoding large amounts of data due to the additional degree of freedom, separation of details, compensation of poor image quality, and in catching the user's attention [13, 17]. However, there are also challenges. The use of S3D can cause fatigue, eyestrain, and headache [13]. The brain combines depth information from multiple cues to form an understanding of a 3D image [14]. This processing of the stereoscopic images requires mental effort. Creating optimal visual ergonomics and viewing experience is challenging and has been addressed in several studies [5, 15, 20]. When studying interaction with 3D content, the use cases so far have been quite different from our work. Prior art focused on investigating 3D object manipulation and touch-screen based interaction (see [26, 28]), whereas 3D cinema is a novel study context.

Interactive Cinema and Interactive TV (iTV)

Interaction in cinemas has recently gained popularity. In the horror movie "App", users were encouraged to interact with the mobile phone[1]. Interaction was triggered by the use of inaudible sounds that a mobile phone app could detect. With Disney's Second Screen[2], children are able to interact with content as they watch a movie. Finally, Cinime[3] is a mobile application that focuses on entertaining users, primarily before and after the movie. Despite these first commercial attempts that did not include any scientific evaluation, attention from an HCI perspective has been rather scarce. Häkkinen et al. have investigated people's focal attention wtowards S3D movies using eye tracking [8]. When comparing the S3D and 2D versions of the movies, they found out that whereas in 2D movie viewers tend to focus quickly on the actors, in the S3D version the eye movements were more widely distributed among other targets [8]. Pölönen et al. studied on user perceptions related to two S3D films, the science fiction movie Avatar and the music documentary U2 3D [21]. They report that the genre of the film has a significant effect on the viewers' opinions and sense of presence, and that previous experience with S3D significantly reduces the amount of

[1]App Website: http://appdefilm.nl
[2]Disney Second Screen Website: http://disneysecondscreen.go.com
[3]Cinime Website: http://www.cini.me

Figure 2: Example screenshots of the commercial (left) and the movie (right), both including interactive items.

inconvenience related to eyestrain and weight of the viewing S3D glasses [21]. These early attempts on interactive cinema encouraged us to scientifically investigate this concept. Our work expands the boundaries or prior art by focusing new interactivity concepts and 3D content.

Interactive TV (iTV) has received considerable attention in the past. In contrast to our approach, however, iTV follows a broadcast distribution model, making collaboration and competition scarce (e.g., WorldCupinion [25]). Furthermore, the interactive cinema setting fundamentally differs in that it targets a large co-located audience, making it likely for the experience to be different from iTV, which mainly occurs in home settings with few people present.

Mobile Interaction with Large Screens

Our research utilizes two main technologies – large displays used to render 3D content, and mobile devices, which are used for interacting with the content. In earlier research, interaction with pervasive displays has been addressed in several studies summarized by Alt et al. [2]. In this work, the authors explored different interaction techniques for public displays, and report that preferred interaction techniques depend, for example, on the user and their context when interacting with the display. In general however, mobile phone interaction is preferred over public display input with people on the move, tech savvy youngsters, and privacy-aware users [2]. Gesture interaction with a mobile phone has been found to provoke reactions related to social acceptability and making large gestures can be perceived as distracting or odd looking [23]. However, gesture input with the mobile device in hand has the benefits of eyes free interaction. Particularly with touch screen equipped smart phones, eyes free interaction is difficult as the touch screen input does not provide haptic cues similar to hard keys.

Kauko et al. compared two interaction techniques, distal and proximal selection, when interacting with a large screen with a mobile phone [22]. Whereas proximal selection, where items are selected on the phone screen, was found to be faster for complex tasks, distal selection, where selecting the targets is done by pointing at them on the large screen, was as fast for simple tasks and perceived more fluent, as it does not require switching the attention from the large screen. In the context of cinema, the interaction design should not require the viewer to switch attention from the movie screen to the mobile phone. Prior work showed that interaction also has a positive effect on cognition. In particular, users that interacted with content on public displays could afterwards recall significantly more content compared to users that only passively observed the same content [1].

Positioning of Our Research

We draw on research from different areas, mainly interaction with mobile phones and user experience. At the same time, our work has novelty in several aspects. It goes beyond the prior art, focusing on the interactive movie concept rather than the viewing experience of static 3D [8, 21]. The context of use (i.e., a movie theatre) has hardly received attention in HCI research and, again, interactive cinema is a rather unexplored field. Earlier research on interactive cinema has addressed alternative narrative structures and steering of plots [3, 29], whereas we look at the mobile phone based interaction with the movie screen to collect digital extra content from the movie screen.

INTERACTIVE 3D CINEMA

Our concept for interactive 3D cinema is focused on showing interactive 3D content on the cinema screen. The interactive objects are integrated into the commercials and the movie clips, and are shown for a limited period of time. The users can then catch these interactive objects with their mobile phones by performing a gesture, and the collected items are stored on the mobile phone application – either for the purpose of an interactive game or for later use. We explore two different concepts:

- Competition, where users compete against each other in trying to catch as many interactive objects as possible, integrated with a commercial video clip.
- Collecting informative content items, where each user can collect any interesting interactive items without any competition, integrated in a movie clip.

Screenshots of the clips with interactive content are depicted in Figure 2.

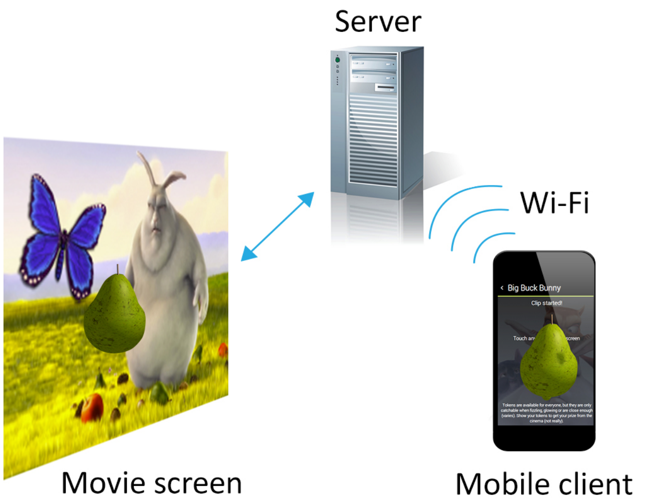

Figure 3: Illustration of the main components of the test setup. Server and client are connected via Wi-Fi.

We explore two different interaction techniques for mobile phone interaction for catching the interactive objects – tapping the touch screen and gesture input (shake). The technical set-up and mobile phone application are explained in more detail in the following sections.

Technical Prototype

We developed a prototypical system using a client-server architecture (see Figure 3).

Server

The server consists of a game engine (Panda3D[4]) that is responsible for displaying the movie as well as rendering the 3D objects in real time and a component that handles client interactions over HTTP. The client mobile application (see next section) requests the state of the clip currently being run and communicates back any user interaction (tap or shake). Success of the interaction, i.e., whether a user managed to catch an item, is then calculated on the server side and the result responded back to the client software.

Since client and server are in the same local Wi-Fi network, the use of HTTP does not introduce a significant latency and the interaction appears to be almost instantaneous. To be able to handle numerous Wi-Fi connections within the same room without causing delays, two commodity wireless access points are configured on the same network. Operating two distinct channels allows for distributing clients evenly between the access points and, thus, balance the load.

Mobile Application

A mobile app enables users to interact with 3D content by retrieving content items as they appear on the screen. Retrieval of content can be triggered (a) by tapping the phone screen, or (b) by performing a catching gesture with the phone.

[4]Website: http://www.panda3d.org

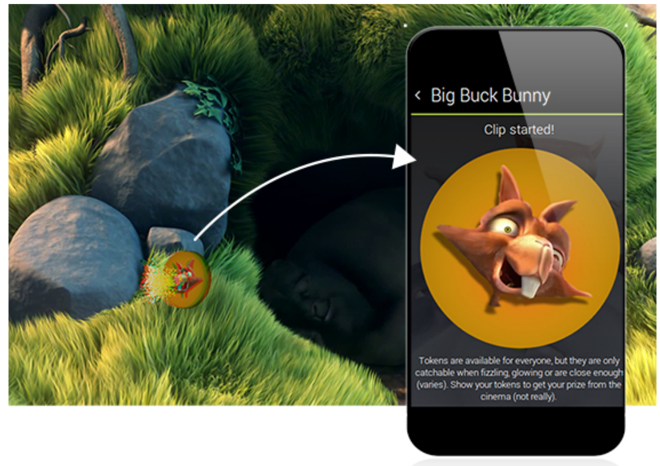

Figure 4: Screenshot of the mobile phone application in the interactive 3D cinema study. Interactive icons could be obtained from the movie by tapping the smart phone screen, where the icon appeared after the capture.

For the client software, we use an Android app that communicates with the communication server to get the state of the clip running and indicating an interaction (tap or shake). For the tap interaction, we used the entire screen of the phone to provide an easy and eyes-free interaction. For the shake interaction we used the accelerometer data and simply detect shake gestures by defining a certain threshold (i.e., more than $25\,m/s^2$ acceleration). Success of the interaction is calculated on the server and responded back to the client. The phone then displays the caught item for 1 second and vibrates for 2 seconds to provide feedback to the users.

The mobile app currently supports two different modes: a competitive mode and an informative mode. In the competitive mode, content items can be collected. This mode is mainly meant for games, for example, in the form of commercials, where the audience can compete for an incentive (e.g., an ice cream) by collecting as many items as possible. For each collected item a symbol is shown on the screen. Depending on the game setting (server), only the first n users to perform the interaction as content items appear will collect the item. In the informative mode, people can retrieve meta-information. This mode is means to be used during motion pictures to enable viewers to retrieve information on actors, the name of the song currently playing, or a screenshot of the current scene as a background image. In this mode, each user performing the interaction will receive the information. The UI when collecting an interactive item is shown in Figure 4.

The Movies

Interactive Items

During the evaluation we were particularly interested in how interactivity of an item within 3D clips could be communicated to the user, and how users would perform using the mobile phone interaction techniques, tapping and gesture. We use three interactivity cues: 1) glow, 2) particles flying from the object, and 3) no additional visual cues but depth. The interactivity cues are presented in Figure 5.

Figure 5: Examples of interactivity cues applied to a can and used in the study (from left); glow, particles, and depth (movement towards the user along the z axis).

The depth only cue was included as a baseline condition, as we were first interested whether using depth only would be perceived as a sufficient cue to indicate interactivity. Hence, in this condition, we simply let interactive items float towards the user. In prior art, glow has been found to be a visual effect that is perceived particularly well when it comes to indicating interactive items in 3D virtual world user interfaces [19]. Finally, small particles emitted from the object are selected as the third cue, as this visualization has been earlier used in computer games. Note, that glow and particles are used in combination with depth. In the commercial clip, the we also add a movement of the object towards the viewer.

Only one interactive item appears at a time on the cinema screen with one cue applied. The overall number of interactive items was 30 per clip for the competition case (10 for each visualization technique) and 30 per clip for the informative content item collection. The fraction of the screen space taken by an appearing collectable item is approximately 2% in both cases. Each item is shown for approximately 8 seconds – although in practice the time was shorter in the competitive mode, since catching the item causes it to disappear from the movie screen.

We prepared different pieces of interactive 3D content (Figure 2). A professional designer created all content in Blender.

Commercial

For the competition concept, we use a commercial video clip (appr. 1 min), which was edited to be approximately 6 minutes long by repeating it over. During the commercial, we show altogether 30 interactive items (soft drink cans) that users can catch with their mobile phone. The items utilize three different visualization techniques (10 items with each interactivity cue), and their order is randomized. All items are shown as moving towards the audience, and they become interactive approximately two seconds after their appearance on the screen. When the first user catches the item, it disappears from the screen and is shown on the mobile phone of the "winner". As we have two interaction techniques, tapping and gesture, we created two randomized clips.

Movie

For the informative content collection concept, we chose the "Big Buck Bunny" movie, an open movie created with Blender. We augmented the movie with certain items, which, if caught by the viewer, would transfer meta-content of the movie (e.g., information on the characters, a soundtrack, background images) to the mobile phone of the user. Altogether, 30 interactive content items appear during the 10-minute movie clip. We created two versions of the interactive movie – one with glow and sparkle effects (no movement), and the other one with interactive items that move towards the audience. This decision to include less content items compared to the commercial was made to leave more space for the immersive experience with the movie, as we found approaching items to be quite dominating when testing.

Figure 6: Participants of group 1 answering the questionnaire in between the video clips.

EVALUATION

In the following, we describe the evaluation of our concept in a cinema setting, using the technical prototype described in the previous section.

Procedure

For the purpose of the study we rented a commercial movie theater with 45 seats (Figure 1). The dimensions of the screen are 4.5 m x 2.5 m. People were recruited in the days prior to the study via mailing lists, Facebook, and a local online forum. Participants were offered a movie ticket for their participation. When recruited, participants were told that they could use their own mobile phone (Android 2.2, 2.3, or 4.x) or they were provided with a phone for the duration of the study. We run two user study sessions (with 11 and 9 users), each lasting for an hour. Two study sessions were organized to counterbalance between the different interaction techniques and movie visualizations.

As participants arrived at the cinema, we briefed them about the purpose of the study and had them sign a consent form and background questionnaire on demographics and earlier experience with 3D. Following the briefing, researchers helped them to install the mobile application on their phone. After that, participants were handed out anaglyph glasses and questionnaires for the study. Then the participants were asked to take a seat in the theater (Figure 6). Here, we observed people sitting both alone and in the groups of 2-3 people.

The actual study consisted of the following steps:

- Stereovision test
- Commercial, clip A (group 1: tapping; group 2: shaking)
- Commercial, clip B (group 1: shaking, group 2: tapping)
- Movie (group 1: clip A with glow and sparkles; group 2: clip B with objects moving towards audience)
- Movie (group 1: clip B; group 2: clip A)

After each step, the participants had to fill in a questionnaire. Questions concerned the interaction techniques (tap and gesture), the interaction cues (glow, particles and depth only) and a comparison of the two presented concepts. The steps in the test procedure are described in more detail in the following paragraphs. The stereo vision test consisted of three images (stereoscopic photos of camera, car, and flowers) and participants were asked to describe what they see and whether seeing the photos is easy, hard, or impossible.

We then moved on with the first part of the study where we showed participants a set of commercials. We told the participants that several items in the commercials were interactive and could be caught by means of the smartphone. We explained them both the tap and the gesture interaction and told them that at the beginning of each commercial there would be an indicator, which interaction technique to use. However, we neither told them which items were interactive nor revealed how they could determine the interactive items. Additionally, we told that only the first person to execute the interaction would receive the item and that the person who at the end of the session collected most items would receive two free movie tickets. After that we played the video clip repeating the commercial 6 times (6 minutes in total), each with a different combination of interactivity cues. After the commercials we provided the users another questionnaire that asked them to answer a set of questions on the interaction techniques and interactivity cues.

After that we proceeded with the main movie. We told the participants that during the movie several interactive items would be shown that would provide them meta-content of the movie. We told them that they could collect items upon interest and that there would be no competition among the viewers. During the instructions, we also showed them the interactive items and their meaning (i.e. extra information on the characters, concurrent movie scene, or music). To interact with the movie, only one interaction technique was available (tapping). After the movie we provided them a final questionnaire assessing the user experience.

Participants

Altogether 20 subjects participated in the study, aged from 20 to 29 years ($M = 25.7$, $SD = 3.10$). In total, 7 out of 20 were female. The majority (14/20) visits a cinema theater approximately 2-3 times a month. 15/20 participants do not have 3D gadgets at home to watch 3D content. Altogether 7/20 do not use any vision aids, whereas the rest of the participants reported wearing glasses or contact lenses. The stereovision test revealed that 19 out of 20 are able to easily see stereoscopic content on the movie theater screen. One participant with glasses had some difficulties due to the anaglyph glasses she had to wear on top of her own glasses. None of the participants reported suffering from color vision deficiency.

Adjective	Chosen by n participants
Responsive	8/19
Playful	7/19
Visually pleasant	7/19
Easy to use	6/19
Approachable	6/19

Table 1: The five most frequent terms describing the overall interaction experience with 3D movie and objects, n=19 (one participant excluded for not completing the task)

Data Collection

The written survey consisted of open-ended questions, ratings on Likert scales, and word picking tasks adapted from Microsoft Product Reaction Cards (PRC) methods [4]. With PRC, participants selected five words of the provided list of 52, which consisted of 26 pairs (e.g., inspiring, uninspiring). In addition to the written survey, we logged the user interaction with the interactive items during the user study. For each user we recorded the time between the appearance of an interactive item and the execution of the catching interaction. In addition, we logged the items that were collected.

RESULTS

Interactive 3D Cinema Concept

The words describing the experience with interactive 3D cinema concept collected with PRC method [4] after the study are presented in Table 1. Overall, seeing and interacting with 3D objects during the movie is perceived as a positive experience according to participants. Open feedback responses from 6/20 participants indicate that interactive 3D content takes attention away from the actual video clip (see Figure 7). Two participants (#1, #20) want to see interactive content follow more the actual story line. *"It would be great, if the objects would appear according to the plot of the movie."* (participant #20). Due to its occupying nature, users suggest 3D object interaction to be used in short clips and commercials. *"Good for commercials and short clips, but not for the whole movie"* (participant #8).

Competing Against Other Viewers

The two different interactive cinema concepts (i.e. competition and informative item collecting) received both positive and negative comments. According to open text responses, 13/20 participants appreciate the opportunity to compete against the other viewers and win something. Competition occupies focus and concentration efficiently and results in immersive experiences. *"I liked the competition, but once I got excited with the game, I couldn't concentrate on the clip at all."* (participant #1). On the downside, failure in the competition results in negative feelings afterwards. *"I like winning. I could catch only one can which reduced the enjoyment of the game."* (participant #10). During the four competition sessions, on average 6/20 participants per group managed to catch cans. Each can could be collected only once.

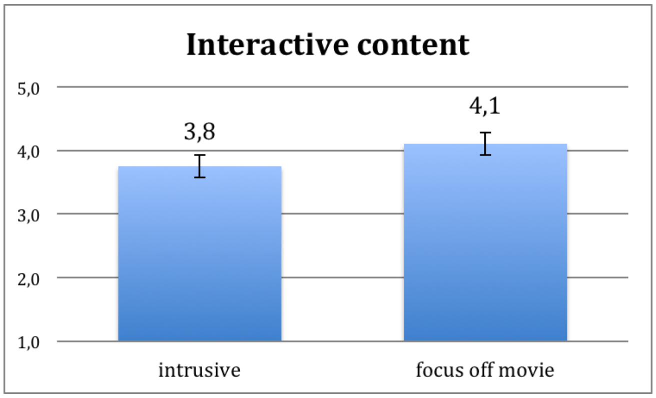

Figure 7: User perceptions of the interactive content (intrusive, focus off the movie) in the scale 1-5. Error bar describes the standard deviation.

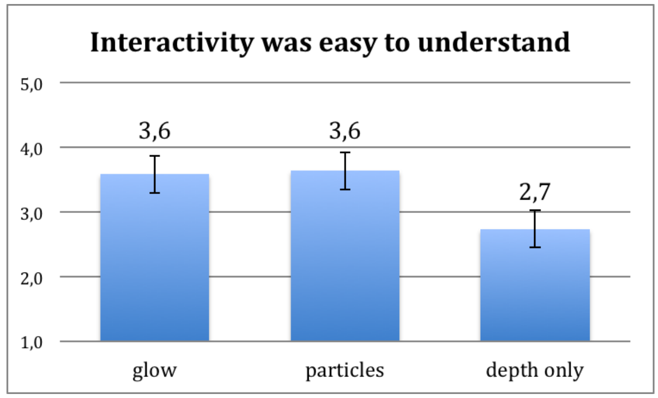

Figure 8: Participants' perceptions on how well the effect represented interactivity. Error bar describes the standard deviation. Results show no statistical differences.

Collecting Informative Items

In the collection mode, viewers were able to collect the items they wanted. Thus, they did not have to catch all the objects shown in the movie. Gathering specified items from the movie is experienced as a personal activity; the selected items reflect participant's own personal preferences and interests. *"I liked the idea that I can collect objects that interest me personally. This made the experience more pleasant and less stressful than during the competition."* (participant #7). The open-ended results show that the possibility to get extra information about the movie by collecting items is regarded as a useful function by 11/20 participants. *"This would be a good way to learn about characters and movie scenes."* (participant #4). Interestingly, we received quite strong feedback from participants who feet disappointed with their performance with the competition, but who like collecting the informative items from the movie. This is demonstrated e.g. in the following comments: *"I liked the collection part of the study. I was happy I could collect the items I wanted. During competition I felt frustrated since I couldn't catch anything."* (participant #8), and *"I was able to actually get the icons which was better than in the coke clip."* (participant #19).

Participants collected in total 458 items ($M = 11.73$ per session, $SD = 5.12$) in all four sessions. Thus, on average each participant collects roughly 39.1% of the items shown on the screen.

Tapping vs. Gesture Interaction

During the commercial clips, participants were able to test and compare tapping and gesture their smart phones for catching 3D content. The questionnaire results show that nearly half of the audience preferred tapping (9/20) and half gesture (11/20). PRC frequencies show that tapping was most commonly described as easy to use (5/19), simple (4/19) but also dated (3/19) way to use the phone for interaction. Gesture was evaluated as playful (7/19), novel (6/19) and easy to use (5/19). Following responses indicate a feeling of immersion with gesture. *"(The gesture creates a) better feeling for playing, and it was exciting (participant #11). Gesture was more physical. There was more action than in tapping?"* (participant #2). Interestingly, we did not receive any feedback on gesture interaction to be socially awkward, even though people were sitting in the movie theater among strangers. Quite the opposite, seeing others shake their phones as well was reported to create a feeling of social activity. *"It was nicer to compete when you could see others shake their phones as well."* (participant #6). An example of participant doing a shake gesture is illustrated in Figure 9.

In the commercial clip tasks, we evaluated the time needed to catch an interactive item presented within the main content. Therefore, we analyzed both interaction techniques. Participants caught the items faster with the tap ($M = 3.17\,s$, $SD = 0.74$) than with the gesture ($M = 3.56\,s$, $SD = 0.90$). We performed a two-way analysis of variance (ANOVA). The ANOVA shows statistically significant differences for the reaction time in the interaction technique, $F(1, 112) = 6.542$, $p = .012$, $r = .232$. This shows that the interaction by tapping the phone is faster than gesture.

Interactivity Cues

Glow and particles were subtle but perceived as sufficient enough indicators of interactivity during the clips (see Figure 8). The depth only cue, where the interactive items were moving towards the audience, was reported to take too much screen space and interfere the movie experience.

The emergent results of the interactivity cues indicate that particles ($M = 3.26\,s$, $SD = 0.72$) performed best, followed by glow ($M = 3.30\,s$, $SD = 0.95$) and no depth cue ($M = 3.54\,s$, $SD = 0.84$) at all. Analyzing the interactivity cues, the ANOVA shows no statistically significant differences, $F(1, 112) = 1.350$, $p = .264$, $r = .105$.

Placing the Content

Most participants (15/20) stated that general information about the movie (e.g., music and background image) should be placed in the corners of the screen. More content-related information (e.g., information about a certain actor or product seen in the scene) should be placed next to the subject in matter according to 10/20 participants. In general, the idea of receiving useful and interesting information already during

Figure 9: A participant performing the gesture input with his phone.

the movie obtained twofold opinions. 35% of the respondents do not want to have any extra material during the movie and feel that extra content rather limits the experience. The rest (65%) argues that relevant and interesting information during the movie can enhance the overall experience, if the interaction design is well executed.

DISCUSSION

Experiencing Interactive 3D Cinema

Based on our study, the interactive cinema concept, where people interact to collect items into their personal repository, does provide an interesting potential for the future development. In general, the competition concept is perceived as rewarding and playful, whereas collecting informative items is perceived as useful and personal. The interest and positive comments left us with an encouraging overall perception about the concept of interactive 3D cinema. However, there are a number of findings that should be carefully considered before designing such an application or service.

As movie experience is very much content-driven, it is crucial to avoid breaking the immersion or disturbing the movie. Hence, participants want interactive items to be integrated contextually with the actual media content shown on the theater screen. Additionally, extra content should appear close to the objects (e.g., actor) they relate to. An ideal solution to combine these two design requirements would be to use the interactive items in places where they do not interfere with the movie experience – commercials, trailers, or end scripts.

In terms of Forlizzi's UX framework [7], our concept of interactive cinema provides means to shift the balance from cognitive towards expressive user experience. Whereas the cinema experience is still essentially linked to the action and duration of watching the movie in the theater, i.e., cognitive interactions, there are already elements which extend the experience before and after the theater, such as trailers, advertisements and discussion forums. The approach of collecting and retrieving items and extra content, adds to the existing means and fosters a more personal relationship with the product (i.e., the movie), thus forming an expressive user experience. Roto highlights, how user experience extends also to the time after use [24], and collecting movie related items and take them away, either as information or as tokens, has the potential to further prolong this connection. In addition, the collective information about the audience can offer interesting reflections. For instance, a ranking list of the most commonly collected information items can support the perception of a shared experience. Interestingly, interactions themselves are not regarded as socially unacceptable, which was somewhat surprising given prior work on interaction with public displays [23]. This may be partly due the context, as people are sitting in a dark room, where the visibility towards other viewers is limited. Also, it may have been the case that our participants were immersed with the content of the film and, hence, paid less attention to their surroundings.

Design Considerations

Our study revealed several findings regarding designing for a competition in the interactive cinema. The feedback on collecting the items should be very clear, and it should preferably be designed to create feelings of excitement, delight, and playfulness. To achieve this, one potential option is to use some special effects in the interactive items. In our study, the glow and sparkle effects were well received, but additional effects could be added, e.g., on how the interactive item appear or disappear on the screen. Here, the graphics and animation design could also be matched to reflect the movie genre. Also, in the competition, participants want to know more about their fellow competitors, not just their own performance. The opportunity to know something about the rest of the audience, for example, winning scores shown on the large cinema screen, would create a common experience and the feeling of being together in the common place.

Another important thing to consider relates to the overall user experience with movies. People often go to the cinema to relax and feel good, or to immerse themselves with emotional or exciting scenes, and it is important to design for such an experience. In the context of competition, this means that the interaction should provide positive experiences to avoid situations, as in our study, where some participants felt very disappointed about not catching interactive items even though they thought they were doing well. A possible solution to this is to reward not just one person but for example the first 30% of the users that catch an item, or provide them with other inspiring or positively surprising UI feedback. In the middle of a (supposedly) relaxing and refreshing situation (the cinema), the user should be able to achieve positive experiences, and not feel ignored or disappointed.

From a design perspective, presenting interactive items in a sequence, i.e., not several items simultaneously, was a good solution, as it did not require switching attention from the movie screen to the mobile phone – tapping anywhere on the touch screen would suffice.

Limitations

Our study has several limitations. First, the sample size was small ($n = 20$), but we believe to have tested the concept with a sufficiently large sample to gather early insights.

Second, the movie experience was different from a "real" visit to the cinema, and although we wanted to study an as authentic environment as possible, we acknowledge that the study setting was artificial. While we believe the commercial task to be quite realistic, the main movie clip lasting approximately for 10 minutes was rather short. We deliberately decided to limit the length of the videos for not making the study too long (1.5 h). This also ensured that participants optimally remembered their impressions when interacting with the system. Consequently, the length of the clips corresponds rather with trailers and ads shown before the main movie. Nevertheless we believe that the movie clip was long enough for the users to give an initial perception of the overall experience. In addition, it should be noted that the design of graphics and animation elements should preferably be aligned with the movie genre. Our study was limited to a cartoon style movie, but alternative effects should be explored for different movies genres, for example, for action or horror. While showing a full-length movie would be very interesting, we think that this should be subject to a separate study planned for the future. For future work we aim to test full movies and take into consideration how interactive elements should be integrated unobtrusively.

Third, in our study, we opted to let participants use their own phones since (a) an unfamiliar phone may have had a positive or negative influence on the experience (form factor, distraction, etc.) and (b) in this way we expected the external validity of the results to increase. During the development, we tested the software on different phone models, and in addition, on every participant's phone. Since all participants connected to the same WiFi hotspot, we expect differences for technical reasons to be minimal. All 20 participants collected interactive items during the study, reflecting the successful technical implementation. Given our data we did not find any evidence that different sensors influenced our results.

CONCLUSION

In this paper we have investigated the concept of interaction with 3D cinema content. We explored collaborative as well as competitive forms of interaction. Our results show that people engage themselves with both the content and extra material related to the actual movie. We envision the popularity of such applications to further increase as means are provided for the viewer to retrieve information on the main actor or buy the current soundtrack by just one click during watching the movie or while they play a game prior to the movie.

The finding that interaction was sometimes perceived to be distracting suggests that interaction should be realized in a simple and unobtrusive way that does not negatively influence the cinema experience. For example, retrieved content could be stored for later use and then be brought to the attention of the user as the movie is over. Our findings indicate also that the concept of interactive cinema provides means to enhance both individual and communal experiences in the cinema. Whereas collecting items to your personal devices makes the experience more personal and lasting, the design of interactive games can be used to create the perception of a shared experience. Our findings also emphasize that designers of interactive cinema concepts should pay particular attention to create positive experiences and reward the users, as feeling good or exited is an inseparable part of the overall movie experience and motivation to attend the theater.

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