Effects of Riddle Solving as a Navigational Method in a Mobile Location-Based Game Experience

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ABSTRACT

Mobile location-based games are experiences that entertain its players by requiring interactions mainly at points of interest (POIs). Navigation between POIs often involve the use of either a physical or digital map, not taking advantage of the opportunity available to engage users in activities between POIs. The present paper examines, how riddle solving as a navigational method in a family location-based game experience affects enjoyability, compared to a 2D digital map. 10 families with 2-6 persons and at least one child in the age range 9-11 years old participated in the evaluation of a location-based game experience called *Lost on Earth*. Statistical evidence that riddle solving as a navigational method is more enjoyable than a 2D digital map was found using questionnaires. Findings from video recordings, field notes, questionnaires, logging and semi-structured interviews also revealed that riddle solving as navigational method in mobile location-based games has potential in engaging users in learning activities.

Author Keywords

mobile location-based game; family experience; enjoyability; navigation; riddle solving; maps;

INTRODUCTION

Mobile technologies are increasingly being used to create experiences in the context of museums and cities. Families and children in particular are an ideal target audience in this context, due to the rising trend of families owning mobile devices [29]. Previous studies concerning engaging children and families have looked into game experiences inspired by treasure hunts, where the players search for written or visual clues in order to find specific items in a museum exhibit [15][18]. Jensen investigated, how children can be motivated to engage in a joyful museum experience, by interacting with an agent and taking pictures of art works on a tablet device [15]. This experience was inspired by a paper version of a treasure hunt, similar to the one investigated by Larsen & Svabo [18]; a treasure hunt in pamphlets. Children were dependent on their parents reading out the questions, interpreting the answers and writing them down, making it a family-activity rather than a child-activity [18]. We address these experiences and refer to them as *mobile location-based games* (LBGs). Common to LBGs are that they place in a *physical space* (e.g. require going to a specific physical location), require some interaction by the player in the *virtual space* (e.g. solving puzzles, interacting with an avatar or following a map), resulting in an interplay between the physical and virtual space [2].

Upscaling such experiences at museums to the city context, we did not find any studies on LBGs targeted families. However, we did find that activities in LBGs that take place in cities resemble those in museums; Players navigate between points of interests (POIs), A and B, in the physical space and a mobile device is used as either (1) aid to get from A to B (e.g. using a digital map to navigate from one exhibit or cultural heritage to another) or (2) for some activity at the POIs (e.g. getting information, interacting with an artefact or taking pictures). From previous research, we found that a common tendency for LBGs is that the player simply uses either a physical or a digital map utilizing the Global Positioning System (GPS) for navigation between A and B. Since the purpose of LBGs is to create enjoyable experiences by creating an interplay between the physical and the virtual world, we hypothesize that a navigational method with LBG activities in the navigation instead of a map can increase enjoyment of the experience. In order to evaluate the effects of such navigational method, we designed and implemented a location-based game, *Lost on Earth*, aimed at families. The game was based on the previously mentioned museum experience by Jensen [15], targeting 9-11 years old children. In the following paper, we describe the design end evaluation of this game.

BACKGROUND

Avouris & Yiannoutsou reviewed fifteen LBGs and categorized them as either games designed for player enjoyment (ludic), education (pedagogic) or a combination of both (hybrid) [2]. Most of the LBGs at museums, where e.g. children interact with museums exhibits fell under the hybrid category. The authors found that LBGs take place in a *physical space* (e.g. going to a specific physical location) and require some interaction by the player in the *virtual space* (e.g. doing riddles/puzzles, interacting with an avatar or following a map). This results in an interplay between the physical and virtual space, creating what is known as the game space/narrative space [2]. They also found that narrative was an underlying element in all LBGs [2]. From this, we define LBGs as *game experiences* that connect the *physical space with the virtual space* and make use of an underlying *narrative* element.

This paper focuses on the integration of the terms mentioned above into the navigation between POIs in LBGs. Therefore, the following sections will provide a more detailed definition of these terms followed by an analysis of how navigation is used within hybrid LBGs that take place in cities.

Activities in Location-based Games

In order to describe the game activities of LBGs, it is first important to look into what constitutes a game. There are a range of different definitions of games, however McGonigal proposes four defining traits of games which fit the scope of this project. Games must have a *goal*, *rules*, *a feedback system*, and *voluntary participation* [20]. The goal of the game is the specific outcome which players aim to achieve and what gives players a sense of purpose. The rules set limitations or remove obvious ways of getting to the goal and push players to be creative and use strategic thinking. As mentioned by McGonigal, an example of these fundamental traits can be seen in the game *Scrabble*. In this game, the goal is to spell out long words with lettered tiles, while the rules are that players only have seven letters to work with at a time and they must be based on words that other players already have created. The feedback system informs players about their progress in achieving their goal e.g. through points, levels, a score, or a progress bar. This gives a promise to the player that the goal can be achieved and thereby provides motivation to keep playing. Voluntary participation requires that all players accept the goal, rules, and feedback. This establishes a common ground for the players to play together, and the freedom to enter or leave the game ensures that stressful or challenging work is experienced as a safe and pleasurable activity.

Hybrid LBGs are designed both with the purpose of player enjoyment, by using elements from ludic LBGs, as well as educating them about e.g. cultural heritage, by using elements from pedagogic LBGs [2]. In the following, these different types of LBGs will be elaborated on, however due to the scope of this project, less emphasis will be put on purely pedagogic games.

Although the focus of ludic LBGs is enjoyment, learning is often an implicit element, since players might develop skills such as exploration and orientation e.g. by navigating a city. This is especially seen in treasure hunts, where players typically move to certain physical locations and use the physical space at the location for some interaction in the virtual space. Gentes et al. describe treasure hunts as experiences that encourage people to pay attention to details in the city and read the cityscape by looking for clues. An example of this can be seen in the LBG *Team Exploration*, where players work together to compare pictures in the virtual space to real physical locations in Paris in order to figure out which areas of a map the pictures were taken at [12]. The goal of the game is to reach the final location, which is shown on a map, once all pictures have been located. The limitation is that it must be done within a certain amount of time, however in the evaluation of the game, players mentioned that this limitation turned the experience more into a race, which made it difficult for players to enjoy the city instead. Gentes et al. describe this as a tension that exists in treasure hunts between the attention players allocate to the discovery of a place and the hunt itself [12]. Furthermore, the evaluation showed that players wish they had some proof that they had been at certain locations, e.g. by being able to save a picture of the location in order to make the visit more meaningful. As these pictures would act as proof for progression, this indicates that the ability to save information about the places visited is a fitting way of incorporating feedback systems into treasure hunts. Treasure hunts also typically allow players to collect virtual objects at certain physical locations [2], such as in *Insectopia*, where the players collect virtual insects, which represent points and act as both the goal of the game as well as an indication of progression and feedback system [23].

Pedagogic games explicitly have the purpose of educating the player through informal learning [2]. Informal learning is learning that typically does not take place in classrooms, is not highly structured, and where the control of learning rests in the hands of the learner [19]. Incidental learning is informal learning that occurs when people are not conscious of it, e.g. as a result of completing a specific task [19]. According to Avouris & Yiannoutsou, these games typically have a strong narrative and use role playing by making players enact certain roles to comprehend complex scenarios [2]. In these games, it is assessed that it is particularly important that the physical and virtual have a strong interplay to support learning.

Hybrid LBGs are typically used at cultural heritage sites such as museums [2]. They tend to act as guides for exhibits and aim to make them more interesting. The game activities frequently incorporate a narrative, as described in detail in the next section, through role play combined with activities such as answering questions that are related to the cultural artefact in the physical space. *CityTreasure* is an example of a hybrid treasure hunt LBG where learning is supported through riddles at POIs [6]. In this game, students on a field trip visit cultural heritage sites in the city Lugano and answer riddles in the virtual space related to the POIs in the physical space. The students play in groups and are guided to the POIs through locations on a map, and as they reach the locations, they are given three riddles related to the POI. When the riddles are answered, the students will be given a new location on the

map to walk to as well as feedback in the form of points if the answer was correct. The goal of the game is to gather the most points, which is driven by competition between the different groups of students playing. Furthermore, Botturia et al. reported that the game fostered collaboration within the groups to solve riddles [6]. In opposition to *Team Exploration*, there is no time limit in *CityTreasure* and by rewarding players' observations of the city through points, exploration is encouraged. Although this game does not focus on role play and narrative as the majority of pedagogic and hybrid games, it still manages to incorporate knowledge of the physical space while keeping players engaged according to the evaluation of the game [6].

Narrative in Location-based Games

Different disciplines (e.g. narratology, linguistics, literary studies, film studies and philosophy) define narrative with a great number of different characteristics [14]. A narrative can be defined as *'a perceived sequence of non-randomly connected events, i.e., of described states or conditions which undergo change (into some different states of conditions)'* [31]. When looking into interactive narratives, it is important to understand the concept of player choice. The quality of a game design can be characterized by looking at the relationship between the players choice and the systems response [27]. This relationship should both be supported in terms of the feedback system of the game such as receiving points, known as *discernable* relationships as well as in the larger context of the game, affecting the overall goal, where the outcome of the game should rely on players' choices, known as *integrated* relationships [27]. This can be related to interactive narratives, which offer players choices and the ability to navigate within a multi-linear branching structure of the narrative, thereby influencing the narrative [26].

Khaled et al. highlighted, how an interactive narrative can be used to explore both the physical space, but also the virtual space. They investigated a location-based experience called *StoryTrek* in which the story develops as the user moves in the physical space. The authors observed four test subjects and found that contrasts between what happend in the narrative space and the physical space forced the user to pay close attention to the physical setting, in order to make sense of the experience. When the users had a heightened awareness of both the physical space and virtual space, reflections on story content occurred [16]. A qualitative study made by Blythe et al. investigated the enjoyability of an LBG called *Riot!* [5]. In this game, users experience a story through sound that changes dynamically in relation to their location in a city, promoting a strong interplay between the physical and virtual space. Results from 30 semi-structured interviews (the exact number of participants were not promoted) revealed that making blind choices caused disappointment, as users were not able to chose specific audio files to hear, since no information about the files was given. Despite of that, *Riot!* did score high on enjoyment, indicating potential in using sound to create a strong interplay between the physical and virtual space. However as the following section reveals, using sound also has some difficulties in the context of families.

Navigation in Location-based Games

As seen in the examples mentioned earlier, location-based games (LBGs) utilize points of interest (POIs) in their gameplay, which brings up the requirement of navigating between POIs, when the games take place in cities. This brings up opportunities to gain additional knowledge of the city during navigation, and not solely at the POIs. From research into existing LBGs, we found that the potential in getting familiar with the city while walking has not been fully utilized, since LBGs often focus on activities at POIs, rather than on when being between POIs. One examples is a study by Gordillo et al., who made a hybrid LBG in the city for tourists [13]. The game offered three POIs which were marked on a 2D map, requiring the users to go there in order to trigger activities provided at the location. One distance required travelling 3 km (from Güell Park to Casa Batllò), bringing the game to a pause until arrival at the POI. The outcome of the study is unknown, as no test was carried out. Previous studies revolving around the navigational aspect within LBGs are similarly also limited, e.g. in terms of evaluating the navigational aspect. From this, we assume that the navigation in the study by Gordillo et al. mainly served as a requirement for leading the player from one POI to another and not as a part of the game activities.

Several LBGs have used 2D maps utilizing the Global Positioning System (GPS) technology (e.g. Google Maps) in a city related context, in order to guide their participants to POIs [9, 13, 34, 7, 3, 24, 4]. To the best of our knowledge, none of these have integrated game activities, such as those that are found at the POIs into the navigation. Therefore, we assume that game activities such as answering questions about the physical space and gaining points either disappear or serve no purpose until the arrival to the POI. Furthermore, we have not been able to find any studies that investigate or evaluate whether navigating with a 2D map is preferable in the context of LBGs.

In the previously mentioned study of *Riot!* [5], players navigated freely in a restricted area. However, its design may only be appropriate in a small bounded area due to the extended freedom of exploration, and could be problematic if transferred to a wider context (e.g. an entire city) due to longer distances between POIs. Epstein & Vergani made a similar study on a walking tour in the city Venice, which likewise incorporated the narrative space into the navigation, but instead kept a more linear narrative structure [11]. A narrator in the application verbally explained where to make turns, and at the same time made comments on the physical environment. The outcome of the study did not reveal the users' experiences concerning the navigation. Both Blythe et al. and Epstein & Vergani encourage the user to explore, but only in relation to the person handling the application due to the use of headphones. Our context deals with families, which would require sharing information. Utilizing sound without it being communicated through headphones would also be problematic in terms of navigating in areas with many sounds.

Eguma et al. devised a LBG for tourists utilizing a sightseeing navigation system to promote awareness of surroundings

and enjoyability [10]. The authors proposed creating a navigational system using augmented reality (AR) to display descriptive information from air tags and upon arrival, the participants would have to seek out a character in the surroundings. The concept does however make use of a map, in terms of leading the participants to the area requiring AR for navigating. The aim of the system was letting the user become aware of the surroundings, using '*benefit of inconvenience*', which is the idea of something being inconvenient to find, increasing the desire of finding it. The authors did not conduct a study, and therefore the outcome is unknown.

Other LBGs have looked into using AR combined with physical props for navigation. Morrison et al. conducted a comparative study on a technique called Maplens, which involves displaying location information on a physical map using augmented reality [22]. The authors compared it to a 2D map with incorporated accessibility to read about locations, known as DigiMap. This technique was investigated in relation to Flow, Presence and Intrinsic Motivation (IMI). The MapLens had significantly lower scores than DigiMap in most of the questions concerning Flow, Presence and IMI, but its potential was revealed in terms of social interaction, since MapLens encouraged collaborative behaviour. Morrison et al. found that MapLens did not support what they call, "*playing by moving*", due to its demands of effort, forethought and planning. This behaviour is supported by the study made by Kuikkaniemi et al., where they compared MapLens and navigating by following QR codes [17]. The authors did not find MapLens particularly useful based on observations on the participants. The authors observed that the participants rarely used MapLens, and had technical difficulties in terms of the GPS displaying their correct position. The QR codes were a fun way of navigating both indoors and outdoors, based on non-significant observations, but with no concrete examples on why. The QR codes did not promote any environmental awareness, making the interplay between the physical and virtual domain weak.

As mentioned earlier, hybrid LBGs require a strong interplay between the physical and virtual spaces, supported by game activities and a narrative with the goal of creating an enjoyable learning experience. Based on the above findings in our research, no LBGs have integrated the requirements for a hybrid LBG into the navigation between POIs without relying on sound through headphones, thereby not being suitable for groups of players. For this reason, a new navigational method that is suitable for groups of people, which in our case is families, and that has the potential of integrating both the physical and virtual spaces, is needed. In the following, we describe a navigational method, which we assess to follow the requirements just described. Note that the following is not described in the context of LBGs as it has not been used in other LBGs to the best of our knowledge, in opposition to the other navigational methods described in this section.

Wayfinding using *landmarks* is a navigational method in which objects or structures that mark a locality are used as points of reference, and it is typically used in the communication of route directions [25]. Route directions provide procedures and descriptions that help people build mental representations of the environment they are about to traverse. When following a route, landmarks can be used for re-orientation at decision points such as road intersections and are known as *local* landmarks. Landmarks can also be used for confirming if people are on the right path, known as *route marks*. Finally, landmarks can be used for overall navigation, known as *distant* landmarks. Landmarks can be described by their *saliency*, which defines how much a landmark stands out from the surrounding objects in its environment. Different types of landmarks have different types of saliency. Sorrows and Hirtle categorize landmarks as either *visual*, *cognitive*, or *structural* [28]. The saliency of visual landmarks can be characterized by their visual contrast to surrounding objects, e.g. based on the size, shape, position or age of a landmark. For *Cognitive* landmarks, the saliency depends on the meaning of the landmark, e.g. due to the landmark being culturally or historically important. The saliency for structural landmarks depends on the accessibility of the landmark, e.g. the amount of locations a landmark is visible from.

As wayfinding using landmarks is a navigational method that uses objects in the environment, we see potential in using it in combination with game activities between POIs for LBGs due to its inclusion of objects in the physical space. This could result in a stronger interplay between the physical and virtual spaces during navigation between POIs in LBGs. Furthermore, using landmarks is based on vision instead of sound, indicating that it might be suitable for a group experience. Therefore, we see potential in using landmarks in combination with game activities as the navigational method between POIs for a LBG targeted families. As mentioned earlier, LBGs have a tendency of using 2D maps with GPS for navigation between POIs, however to the best of our knowledge, no LBGs have used landmarks for navigation between POIs. We set out to investigate the enjoyability of using landmarks in combination with game activities for navigation between POIs with the following research question:

How does landmark navigation in combination with game activities between POIs affect the enjoyability of a location-based game experience for families?

DESIGN

In order to measure enjoyability of landmark navigation in combination with game activities in a location-based game (LBG), we developed a LBG that takes place in Aalborg, Denmark and the area of three street art paintings [1] that were used as points of interest (POIs). The game makes players walk between the three POIs on a route with a total length of 1.8km and a distance of 0.9km between POIs (see Figure 1). Due to requirements from the method of the experiment as described in the Experiment section, the particular route was chosen on the basis of it having approximately the same amount of intersections in the road between POIs, as well as approximately the same distance between the POIs.

Choice of Navigational Game Activity

In the process of designing the navigational game activity using landmarks, four initial designs were created as paper pro-

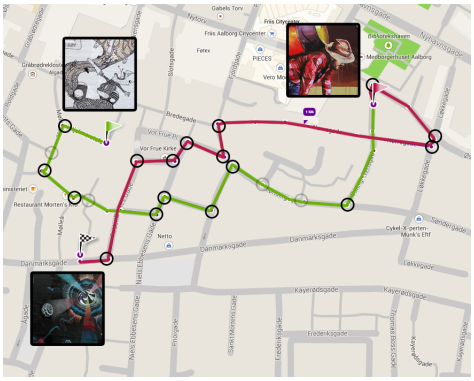

Figure 1. The route between the three street art paintings.

totypes and one was chosen to be used in the game on the basis of a preliminary test on three families. The tests were carried out using within-subjects design, meaning that each group of participants used a specific navigational game activity for each quarter of the route. The purpose of the tests was to determine which game activity the participants found most enjoyable, based on a questionnaire and short semi-structured interviews conducted between game activities as well as after trying all four activities. The participants of each test were a child in the age group of 8-11 years old and the child's parent. We followed the participants during the activities, documenting the tests and interfering, if they got lost or had other problems. The initial designs were paper prototypes with a focus on the navigation.

When designing the four navigational game activities, inspiration was taken from popular children's games, since they are familiar to most children, causing a lower learning curve for the families. Similar game activities were also found in other LBGs at POIs, giving inspiration for how they should be used in a LBG. Three navigational game activities were made as variations of matching card games such as *Concentration* [33]. In these types of games, players specify two or more cards that are alike, among a set of cards, and the goal is typically to be the player with the most matches in the end. In *Team Exploration* [12], players matched pictures in the virtual space to landmarks in the physical space and progressed in the game by specifying which pictures belong to certain areas of a map. Similarly, players are given pictures of landmarks in our three matching game activities; *Simple Matching*, *Order Matching*, and *Memory Matching*.

For all game activities, local landmarks are used to help players choose directions at decision points, and route marks are used along streets to confirm to players that they are walking in the correct direction. In Simple Matching, players are given a set of potential landmarks, where only one of them is a true landmark in their current location. When they spot or match the landmark that is shown on the picture, they go to its position and start matching the next set of pictures. This activity proved to be the easiest of the four and most participants found it to be uninteresting due to its lack of challenge. Order Matching is very similar to Simple Matching, as the only difference is that players have to specify the order in which the presented landmarks occur from their current position. Participants found this activity to be a bit more challenging, however due to the requirement of ordering landmarks, participants sometimes walked back in the direction they came from. Through observation, it was clear that the participants collaborated more in this activity due to the increase in difficulty. In Memory Matching, the landmarks to be ordered are only presented quickly before navigating. When participants then reach the last picture in the set, they are asked to specify the order of landmarks encountered. Through observation and interviews, it was clear that participants found this activity to be the most challenging of all matching activities. This also caused participants to collaborate more, where they e.g. each would remember half of the pictures. Furthermore, participants mentioned that only being able to look at the pictures at certain points, caused them to look more around and notice the environment during navigation.

The last game activity designed was based on riddles, where similar to the game *I Spy* [33], players must spot a specific object in the vicinity based on a sentence hinting about attributes of the object. Based on I Spy and the LBG *CityTreasure*, where riddles are used at POIs, we designed an activity where riddles hint about the next landmark to go to. As in I Spy, the riddles describe attributes of objects through hints. In the context of landmarks, the riddles describe saliency based on the visual, cognitive or structural attributes of the landmark, either in isolation or in combination (E.g. *"I am tall and you can see through me"*). In order for players to confirm that they have found the landmark, they are also given a control question about the landmark with three possible answers (E.g. *"What does the sign beneath the things you can see through say?"*). This was a solution to the problem of specifying the players' exact position through GPS, since at the time of designing the activity, we observed that accurate positions could not be given through GPS. Furthermore, this control question allows for the possibility of including knowledge about the landmarks in the game activity, thereby supporting pedagogic elements in the game. By being able to confirm if the player has found the landmark, it is possible to create a feedback system in the game. Upon answering the control questions, regardless of the players' answer, a picture of the correct landmark is shown to the players, so they never get lost. Through interviews, we found that most participants preferred navigation with riddles due to them being the most fun. It was also clear that of all activities, riddles were the most challenging for the participants, mainly because people were unsure of the scale in which the landmarks could be found. This is due to the fact that participants have nothing visual to compare to in opposition to the matching activities. However, it could also be seen that this limitation contributed to the enjoyability of the activity. We also observed that this limitation caused participants to collaborate and in general communicate more during navigation. Based on these results, there were strong indications that navigation using riddles was the most enjoyable activity. For this reason, riddles were chosen as the navigational game activity to be used in our experiment. In order to test the navigational game activity in the context of LBGs, we designed and implemented the LBG described in next section.

Lost on Earth

Lost on Earth builds on the LBG *Monsters Eat Art* [15] made by Jensen for an iPad device. Monsters Eat Art is an interactive museum exploration game, where children in the age group 9-11 years find specific artworks based on certain details given. When children find the specific artwork, they use augmented reality (AR) to register the artwork in the game and get feedback. Furthermore, Monsters Eat Art has a narrative with a monster, which eats artworks, and the goal of the game is for the monster to eat a specific group of artworks. A sense of progression is given to the player, since the monster is coloured more black, as it eats the artworks. The monster gives the player feedback and integrates the narrative throughout the game.

Similarily, in Lost on Earth, the player assists a monster character (See Figure 2) in reaching a specific goal, using artworks, which in our case is the POIs with street art paintings in the city Aalborg. In our game the narrative is built around the monster being stranded on Earth. Since the players' goal is to find landmarks, we designed a narrative that reflects this, by also giving the monster the goal of finding something specific. As the monster is stranded on Earth, it needs to find fuel for its spaceship to fly home. However, the monster is also looking for its friends, who also are stranded on Earth.

Figure 2. Riddle-based navigation showing the monster character with points in the form of fuels and friends.

Due to the importance of choice and interactive narratives in games, as earlier mentioned, players have the ability to choose whether the monster should look for fuel or friends, which will affect the outcome of the game. These choices are made at the street art paintings. Ideally, different routes should be used for different choices, however to minimize the amount of bias in the experiment, the illusion of choice is given, as the choice will only influence the outcome of the game, not the route to be taken. The choice is made through a dialogue with characters in the street art paintings, which starts as players augment the paintings at the POIs. To incorporate pedagogic elements, information about the painting itself is given through the dialogue, and after augmenting the painting, players unlock access to an info screen about the particular painting. This was included, in order to incorporate the element of saving information about places visited, mentioned previously by Gentes et al. [12] and Peitzl et al. [23], giving the user a sense of progression and feedback.

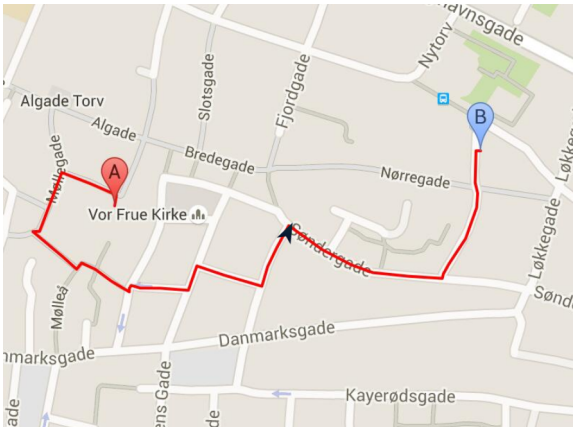

Figure 3. Map-based navigation using map provided by Google Maps showing user's position

In the game activity between POIs, players use riddle solving while navigating, as earlier mentioned. When players start their first riddle, a tutorial introduces how the system works. To incorporate a feedback system, players are given points as they answer correctly on the control questions for the riddles. These points are dependant on the choice made at the previous POI, so for instance in the case that players have chosen to look for fuel, fuel points will be given to the players and vice versa (See Figure 2). Whether the monster will get home or have any friends in the end of the game, will rely on this choice. We also implemented a 2D digital map into the game for the purpose of the experiment. The map had the primary objective of resembling maps used in other LBGs or a even simpler version, showing the user's position on a 2D digital map provided by Google Maps (See Figure 3). As seen in the LBG *Team Exploration*, incorporating limitations in the game such as time, can cause the focus of the game to be more on the hunt itself and not the exploration that takes place in the physical space. For this reason, the limitations used in Lost on Earth are primarily found in the act of navigating itself, where using riddles to navigate is a cumbersome, but also enjoyable way of navigating, as it makes use of the physical space.

EXPERIMENT

The experiment took place over two weekends in central Aalborg, Denmark. Participants used an iPad 2 3G + WiFi as the platform. To investigate the effects of riddle solving as the navigation method in a location-based game, we conducted a comparative study between navigating by riddle solving and navigating by a 2D map with GPS.

Hypothesis

We hypothesized that *riddle solving as a navigational method is more enjoyable than maps.* We came up with the following null hypothesis and its alternative hypothesis.

H0: Riddle solving as navigational method is equally or less enjoyable than maps.

$$H0: \mu EnjoyabilityRiddle \leq \mu EnjoyabilityMap$$

H1: Riddle solving as navigational method is more enjoyable than maps.

$$H1: \mu EnjoyabilityRiddle > \mu EnjoyabilityMap$$

Participants

We recruited 10 families of 2-6 persons through posters and flyers at schools. As the narrative of the game was targeted children, it was a requirement that the families had at least one child in the age range 9-11 years old. 17 children participated with ages ranging between 7 and 13 (mean = 10.1, SD = 1.6), 9 females and 8 males. 14 adults participated with ages ranging between 36 and 62 (mean = 42.3, SD = 6.4), 4 females and 10 males. All participants lived in the city Aalborg or nearby, and were familiar with the city (4 went to the city daily, 5 went to the city weekly, 18 went to the city monthly, 4 went to the city yearly). All participants were familiar using tablet or mobile devices (23 used it daily, 6 used it weekly, 1 used it monthly, 1 used it yearly).

Materials and Procedure

The experiment was designed as a within-subjects design with two conditions. (1) A navigational method, where the participants navigated by solving riddles (R) and (2) A navigational method in which the participants used a digital map (M).

These two conditions were counterbalanced with the purpose of reducing the environmental effects met on the route on the results. Participants would either begin with map or riddles, and would end with the navigational method different from the one met in the beginning.

Three street arts, A, B and C, were a part of the experience. The distance from A to B was 0,9 km and the distance from B to C was 0,9 km. Each condition also had approximately same amount of turns, respectively 8 and 7 turns. Each session lasted between 31 minutes and 40 seconds to 50 minutes and 55 seconds. One facilitator and an assisting facilitator were present during the whole session. The facilitator instructed the participants in using the application before the experiment took place, and further helped during the game if any difficulties arised (e.g. participants got lost). For each session, one of the parents was instructed to wear a GoPro with a harness for recording video, while one of the children carried a bluetooth microphone for recording audio. All parents signed consent forms and filled out demographic questionnaires prior to the experience. We gave the child in the age range 9-11 years old the iPad, but they were not forced to handle it the whole session.

LBGs have previously been evaluated using both qualitative and quantitative methods including observational studies, questionnaires and interviews. Morrison et. al. used Flow [30] , Instrinsic Movation (IMI) [8] and Presence - MEC-SPQ [32] questionnaires and successfully evaluated effects such as enjoyability, intrinsic motivation and awareness of surroundings by triangulating with video recordings, logs, field notes and transcriptions of interview data. We used the same approach, based on the success of Morrison et al. investigating similar criteria as our study.

The questionnaires in this study contains questions from the Short Flow State Scale Questionnaire (S-FSS 2), which measures the degree to which flow dimensions characterize the complete experience[21]. The questionnaire also contains questions from IMI (measures enjoyability, tension, effort and perceived competence) and MEC-SPQ (measures spatial presence, allocated attention and suspension of disbelief). Only adults received this questionnaire due to the level of complexity, while children received a simplified questionnaire measuring enjoyability using IMI. Both questionnaires were measured on a likert scale (5-scale), going from 1 (strongly disagree) to 5 (strongly agree). The parents were instructed to help the children to fill out the questionnaire in terms of them having difficulties. Logging, field notes, interview and video data was used for supporting the analysis of questionnaires. Findings from the analysis is presented in the following section.

RESULTS

Observations

During the experiment, the facilitator walked behind the families and took general notes on the interaction of both conditions. It must be noted that the following observations have not been coded, e.g. through video analysis, but are based on general tendencies.

The biggest differences between the two conditions could be seen in regards to the participants' social behaviour. In general, there was more communication between participants during riddle navigation than during map and the topics were different. During riddles, participants primarily talked about the environment and collaborated to solve the riddles, while during map navigation participants tended to talk about things outside of the game, e.g. one child started talking about his soccer practice. However, this mostly tended to happen on long paths without intersections, as these areas require less attention from users during map navigation. From this, it seems that riddles in general require more attention than maps (See Figure 4).

Figure 4. All participants attending to the iPad, trying to solve the riddle

For both conditions, collaboration was mostly seen between the child using the iPad and a parent. Here, the parent would act as an assistant to the child and take over the iPad if the child gave up (See Figure 5). If there were multiple children, the children not holding the iPad would often have a hard time participating in the navigation and would just follow the group. This indicates that the design does not fully encourage collaboration between multiple players, and it is possible that

the collaboration between child and parent naturally arises from the fact that parents are used to assisting their children. During this collaboration however, it was clear that if the riddles were too difficult for the children, but the parents knew the answer, the parents would give their children hints in order for them to solve the riddle. From this, it could be seen that harder riddles encouraged more communication and collaboration.

Figure 5. Child in charge of the iPad (left) and parent assisting the child (right)

Regarding the riddle system, it was clear that a better explanation of the system to the participants is needed. Often participants would answer the riddles without going to the position of the previous landmark first, which caused frustration since participants would not be able to find the landmarks used in the riddles. Especially families that used riddle navigation for the second part of the route, had a hard time understanding the system. This indicates that the tutorial built into the system did not provide clear enough instructions. Furthermore, the riddle system is shortly explained by the facilitator in the beginning of the experiment, and this information might have been forgotten as participants reached the second part of the route.

When navigating using the map, the participants' current position on the map was often slow at updating due to the lack of a proper GPS signal. This caused participants to walk down wrong paths, and it could take several minutes for the signal to be re-established, causing confusion in the participants. As a result some participants ended up reaching the destination by taking completely different paths, and in one case, it was necessary for the facilitator to guide the participants.

Finally, it was observed that people in general looked around and paid more attention to the environment when solving riddles than when using a map. During map navigation, the participant holding the iPad primarily looked down on the iPad, and it was mostly at intersections that participants looked around in the environment. It was also observed that especially when the GPS signal was weak during map navigation that participants looked down on the iPad.

Questionnaires

We used the Wilcoxon Signed-Rank test, based on the nature of ordinal values and because the sample had been exposed to two conditions (riddle solving and map).

All participants found the system using riddles significantly more intrinsically motivating (IMI) than maps (See Table 1). Assessing IMI, we found that enjoyability and effort scores were significantly higher for riddles compared to maps. Riddles also received a significantly higher score than maps concerning total flow. No significant difference was found for presence, but riddles was still favoured in terms of its score.

Table 1. Questionnaire items showing significant differences between riddle-based navigation and map navigation

Item and Wilcoxon Signed-Rank Test	**System with higher mean**	**System with lower mean**
*Item related IMI for **all participants***		
IMI - total(**)	Riddle Mean=4.31	Map Mean=3.64
IMI - Enjoyment(**)	Riddle Mean=4.49	Map Mean=3.46
IMI - Pressure(-)	Map Mean=2.11	Riddle Mean=1.78
IMI - Effort(*)	Riddle Mean=4.30	Map Mean=3.68
IMI - Perceived Competence(-)	Riddle Mean=4.13	Map Mean=3.68
*Item related Flow only for **adults***		
Flow - total(*)	Riddle Mean=3.85	Map Mean=3.60
*Item related Presence only for **adults***		
Presence - total(-)	Riddle Mean=3.07	Map Mean=2.95

Note: (-) = p>.05 and (*) = p<.05 and (**) = p<.01
IMI, Flow and Presence 1-5 scale

We found significant differences when assessing individual questions from the questionnaire (See Table 2). All participants especially found the riddle system significantly more fun and less boring compared to the map version. As previously mentioned, we observed that riddles were able to include multiple family members, which accommodate the fact that all participants had an enjoyable experience.

Adults found the riddles significantly more rewarding and had the feeling of time moving faster compared to the map version (See Table 2). These two questions specifically assess the dimension on having an autotellic experience and the sense of time transformation. As flow involves nine dimensions, these two were the only dimensions to reveal a significant difference. Other dimensions of flow favoured riddles, or were closely tied with maps (0.05 score difference between riddles and maps), except for a flow question revolving on clear goals. Our questionnaire revealed that test participants found the map system had more clear goals (R = 3.31, M = 3.83, p =.174). As the result is not significant, it is however observed that the map did not require much training, and henceforth more intuitive than what we observed with the riddle system. However, participants still favoured the riddle system despite these difficulties.

Children thought they were significantly better at navigating with riddles than maps. In line with that, children also considered maps more challenging, which could provide an explanation on the matter, but this outcome was not significant (R = 2.82, M = 3.33, p = .177).

We performed a multiple ordinal regression analysis on the questions from Table 2 in order to investigate, whether age, gender, condition order or group size served as predictors for the results. In all cases, the results stayed significant, but the condition order had a significant impact on several of the questions concerning enjoyability in IMI. Due to the condition order, the selection of riddles was different for each condition, as well as the route described on the map. Participants met different landmarks on the route based on the condition order, which eventually provided a different experience between conditions.

Table 2. Questionnaire items showing significant differences between riddle navigation and map navigation

Item and Wilcoxon Signed-Rank Test	**System with higher mean**	**System with lower mean**
Items related ***all participants***		
IMI: I thought navigating was fun (**)	Riddle Mean=4.48	Map Mean=3.42
IMI: I thought navigating was boring (R) (**)	Map Mean=2.14	Riddle Mean=1.41
Flow: My attention was focused on navigating (*)	Riddle Mean=4.16	Map Mean=3.66
Items related only ***adults***		
Flow: I found the experience highly rewarding (*)	Riddle Mean=3.93	Map Mean=3.15
IMI: I enjoyed navigating a lot (*)	Riddle Mean=4.29	Map Mean=3.46
Flow: It felt like time went by quickly (*)	Riddle Mean=4.54	Map Mean=3.69
Items related only ***children***		
IMI: I thought I was pretty good at navigating (*)	Riddle Mean=4.41	Map Mean=3.73

Note: (*) = $p<.05$ and (**) = $p<.01$.
IMI and Flow 1-5 scale

From these findings, we can reject our null hypothesis, stating that riddle solving as a navigational method is more enjoyable than maps.

Interviews

Despite results from questionnaires being statistically significant, showing that riddle solving is a more enjoyable navigational method than maps, findings from interview data allowed for deeper analysis into the effects of this method. From interview data, we found that 5 out of 22 children expressed preference towards using maps. One parent mentioned she also preferred map, saying *"It is just always fun to follow a map"*. This parent explained that they were unsure about what to do during the riddle-based navigation and could not remember what they had been told during the instructions.

Another parent mentioned that map was easy and did not make one aware of the surroundings, because the focus was on walking. In general, we found different opinions on whether the different navigational methods made people aware of the surroundings. One parent clearly stated the children were not interested in the map at all. In line with six other test participants, this parent expressed that it was fun to notice things in the environment they usually do not notice when walking by, making it an optimal method for tourists. Opposed to that opinion, another parent expressed that she focused more on navigating than noticing things in the environment. With riddles, one parent felt that the attention was on the next location to go to, while the map made the participant more aware of the city, because there was more time to look around in the surroundings.

When asked if they would use riddles as navigational method, if they were to use it in another city, all test participants agreed and answered yes. Some thought it would be a more fun way of learning the city, finding the way and that it would make it possible to see the city in a different way. However, interview data also clearly revealed that several participants would have enjoyed it more, if the riddles were about more interesting landmarks that gave the possibility to learn more e.g. about the city. Preferably this should be done with the children in mind and a few parents proposed a system that can be adjusted depending on, whether they had any children and adjusted content according to the childrens age. Riddles as navigational method was described as *"fun if you have time for it"* by one parent.

The most used word to describe riddle-based navigation was "fun" (11 of 29 words). This reflected the results from the questionnaires. Other words included exciting, challenging, different, educational and inspiring. Some participants thought it was fun to answer the questions after the riddles, particularly one child mentioned that it was fun to be able to answer correctly to questions. Results from the log further showed a high tendencies of correct answers to control questions (in average 96,9 % of the control questions across all sessions were answered correctly), indicating that the feedback system had an impact on the enjoyability of the game. One parent mentioned that the fun part in the riddle-based navigation was to help each other and agree on what they have seen in the environment. Several parents had a similar opinion and stated that they enjoyed collaborating and discussing the answers with the other family members. One parent said it was fun with riddles,

> "(...) because there was something to discuss. Of course you can also discuss what way to go with the map, but that just gave a different experience."

In terms of group dynamics, it was mentioned that primarily the one with the device was in control (See Figure 4), making it a less collaborative experience. One parent mentioned that they collaborated more, when navigating using riddles and not as much with the map. In order to make it more collaborative, one of the participants suggested making the riddles more difficult, encouraging the participants to help each other. This statement supports the experience of another parent, who mentioned that they only collaborated when there was any doubt, otherwise they just followed the child, who was mostly in charge of the device.

The interview data revealed a tendency to let the child control the device, which was described as following by one parent,

"Then one finds out about something and the other finds out about something else. I felt I gave much of the control to Mikki (the child), because I wanted him to think it was fun."

In one family, the parent stated that it was much more fun for them both, when the child had the device, because the child was better at using the map and tablets in general.

DISCUSSION

Results from our study clearly shows that riddle solving is a more enjoyable way of navigating than a 2D digital map. However, findings from interviews with the families revealed that some children also enjoyed navigating with maps. Children were challenged using the map as well as riddles for navigation, perhaps because they are not used to any of the navigational methods. We found that children thought they were better at navigating with riddles than maps. Similarly, parents were significantly more in flow with riddle-based navigation than with the 2D map, meaning there was a better challenge-skill balance with riddle-based navigation. One of the explanations could be that parents were less challenged by using maps, as they are used to navigate with maps, while riddle-based navigation was just as novel an experience for the parents as for the children. Particularly in the beginning, we observed that our test participants experienced difficulties understanding the rules of the riddle-based navigation, which was supported by the fact that participants spent most time on the first riddle. Questionnaire data also supported this, as riddles scored lower on clear goals. We assume that maps were less challenging to use, despite of the GPS problems that occured during the experiment, and therefore that challenge was one of the reasons why riddle-based navigation scored higher on enjoyment. Furthermore, we also found that children enjoyed answering questions, getting feedback. This supports that incorporating game activities in a location-based experience like this, makes it more enjoyable for the players - even if it is more challenging and unneccessary obstacles have to be met.

We found no significant results about presence, though riddle-based navigation scored higher on making the participants aware of their surroundings. One of the main objectives of this study was to create a navigational method with a stronger interplay between the physical and virtual space. Interview data revealed different opinions on whether participants were more or less aware of the surroundings using riddle-based navigation, where landmarks are used to navigate between POIs. With map navigation, some participants felt that they were more free to notice things in the surroundings, while riddle-based navigation only made some more aware of the landmarks. This might have been due to different levels of engagement and roles that the participants took, but also the more collaborative approach some had in the families during riddle solving.

Despite not being the main focus of this study, we observed some interesting elements in terms of social interaction among participants. Even though we did not find any statistically significant results supporting that participants helped each other more during riddle-based navigation, compared to a map, we found that riddle-based navigation has potential in motivating groups of people, making it a enjoyable group experience rather just a matter of getting from A to B, where one person is in charge. We observed that participants discussed more and that topics revolved around solving the riddles, discussing the landmarks and not on topics outside the activity, as it was the case with map navigation. Though this requires a more thorough analysis of the interaction among the participants, we hypothesize that riddle-based navigation has potential in supporting learning e.g. about landmarks or developing skills in terms of exploration, particularly in group context. Even though enjoyment is the main objective of most LBGs as mentioned by Avouris & Yiannoutsou [2], we recommend looking into riddle-based navigation or similar approaches for informal learning, as this study has shown the potential in incorporating the time spent navigating into the overall enjoyable experience of a location-based game.

CONCLUSION

In this study, we investigated the effects of riddle solving as a navigational method in a location-based game experience for families. We compared this navigational method with a 2D map, which is a common navigational method to get from one POI to another in location-based games. We found significant results indicating that riddle solving as a navigational method is more enjoyable than a 2D map. Though perhaps not being a more intuitive navigational method than 2D maps, riddle-solving clearly suits the scope of location-based game experiences, as it makes use of the physical space to navigate from one POI to another, while also adding more enjoyment to the experience. We recommend looking into using this or similar approaches to create not only enjoyable, but also educational experiences.

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