

In-car Game Design for Children: Child vs. Parent Perspective

Guy Hoffman

Media Innovation Lab
The Interdisciplinary
Center (IDC) Herzliya
P.O.Box 167, Herzliya,
46150, Israel
+972 9 9527656
guyh@idc.ac.il

Ayelet Gal-Oz

Media Innovation Lab
The Interdisciplinary
Center (IDC) Herzliya
P.O.Box 167, Herzliya,
46150, Israel
+972 9 9527967
goayelet@idc.ac.il

Shlomi David

Media Innovation Lab
The Interdisciplinary
Center (IDC) Herzliya
P.O.Box 167, Herzliya,
46150, Israel
+972 9 9527967
david.shlomi@idc.ac.il

Oren Zuckerman

Media Innovation Lab
The Interdisciplinary
Center (IDC) Herzliya
P.O.Box 167, Herzliya,
46150, Israel
+972 9 9527272
orenz@idc.ac.il

ABSTRACT

Family car rides can become a source of boredom for child passengers, and consequently cause tension inside the car. In an attempt to overcome this problem, we developed Mileys – a novel in-car game that integrates location-based information, augmented reality and virtual characters. It is aimed to make car rides more interesting for child passengers, strengthen the bond between family members, encourage safe and ecological driving, and connect children with their environment instead of their entertainment devices. We evaluated Mileys with a six-week long field study, which revealed differences between children and parents regarding their desired in-car experience. Children wish to play enjoyable games, whereas parents view car rides as an opportunity for strengthening the bond between family members and for educating their children. Based on our findings, we identify five key challenges for in-car game design for children: different expectations by parents and children, undesired detachment, short interaction span, poor GPS reception, and motion sickness.

Categories and Subject Descriptors

H.5.2 [User Interfaces]: Evaluation/methodology, Prototyping, User-centered design.

General Terms

Design, Measurement.

Keywords

In-Car Game; Location Based; Augmented Reality; Driving; Children.

1. INTRODUCTION

Car journeys are becoming an essential part of everyday routines. Accordingly, in-car experiences have been receiving growing

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attention from the HCI community. Numerous systems and applications have been studied in the context of car use, from navigation and information systems to location-based games [e.g.: 2, 3, 4, 8, 10]. A unique in-car experience deserving special attention is the family car ride. During car rides, family members spend time together in a confined space, typically with parents in the front seat and children in the back seat. Laurier et al. [9] noted that people sometimes struggle and sometimes delight in regard to travelling in a car together. The car provides a setting where parents and children can converse with one other, play games or sing songs, but it is also a site of potential conflict, for instance over sitting arrangements or control of various systems inside the car [1, 9, 11]. A survey conducted among 2000 British parents revealed that 62% feel happier without their children in the car; 43% feel anxious, irritated or even angry when their children are present in the car; and 55% admit to losing their temper in long car rides with their children [5]. According to the same survey, on average children start to exhibit signs of boredom 29 minutes into the journey. How do parents respond to boredom? 60% lie about the remaining journey time, and seven out of 10 parents bribe their children with sweets and sugary drinks.

An additional option is keeping children entertained throughout the journey, for example with conversations and verbal games, or with various entertainment devices suitable for in-car use, such as portable DVD players, music players, tablets and mobile phones. Mobile phones in particular have been gaining popularity as an entertainment device for long journeys. A recent survey among 1055 Americans revealed that 36% use their mobile phone while commuting [6]. Electronic devices can keep children entertained during long car journeys, but they also direct their attention towards a screen, disengaging them from other family members and from the surrounding landscape.

In this paper we present Mileys – a novel in-car game aimed to make drives more interesting for child passengers, but also strengthen the bond between family members, encourage safe and ecological driving, and connect children with their environment instead of their entertainment devices. Mileys integrates location-based information, augmented reality, and virtual characters. We explain the various stages of the game, and report on a six-week long field study designed to evaluate Mileys. Based on our findings, we describe the differences between child and parent perspectives regarding in-car experiences, and identify five key challenges for in-car game design.

Table 1. Properties of technologies for in-car use

Technology	Utility	Target User	Location-Based	Focus
GPS Navigation System	Functional	Driver	Yes	Outwards
Portable DVD Player	Entertainment	Passengers	No	Inwards
Games for Tablet/Phone	Entertainment	Passengers	No	Inwards
Backseat Gaming [3, 4]	Entertainment	Passengers	Yes	Outwards
nICE [2]	Entertainment	Passengers, Driver (partial involvement)	No	Inwards
Mileys	Entertainment	Passengers, Driver (partial involvement)	Yes	Outwards

2. RELATED WORK

A commonly used in-car system is a GPS navigation system, designed to help drivers navigate to unfamiliar destinations. A study by Leshed et al. [10] revealed that GPS systems alter the way drivers experience spaces and places, because they become immersed in the virtual-technological environment. The authors conclude that in some ways GPS systems disengage people from their surrounding environment, but also have the potential to open up novel ways to engage with it.

While GPS systems are primarily intended for drivers, providing them with valuable information regarding their current route, other passengers can also benefit from this type of information. According to Inbar and Tractinsky [8], sharing in-car information with passengers helps reduce passengers' boredom, increases trust and a sense of inclusion, as well as reduces drivers' level of distraction and cognitive load.

When child passengers are concerned, they are likely to be more interested in games than in navigation or information systems. Several in-car games for children have been developed in recent years.

"Backseat Playground" [4] is a game that presents sequential audio stories according to the player's location. As the car travels through the landscape, a crime story is unfolding. The player takes part in the story by using a set of tools on a hand-held device. Participants in a user study indicated that they felt as if the game was actually going on outside. The game designers emphasized the challenge of uncontrollable movement, as well as the short interaction span at each location.

A similar game [3], developed by the same team as part of the "Backseat Gaming" project, enables two players to interact whenever they come within a specified distance of one another.

"nICE" [2] is a multimodal, collaborative game, played on two multi-touch tablet devices by the passengers in the front and back seat. During the game all occupants of the car are tasked with guessing the contents of hidden images based on several image snippets and audio hints. These snippets and hints can be unveiled by playing different collaborative mini-games. A user study indicated that users were highly focused on the game, neglecting the outside environment.

In sum, various technologies have been designed for in-car use. These systems differ from one another in regard to utility, target user, reliance on location and focus of attention (see Table 1). We set out to create a game for child passengers, which turns them into active participants in the navigation and driving process during family trips. The game, called "Mileys", is a location-based Android application, intended to direct focus towards the outside landscape, instead of only inwards towards the screen.

3. SYSTEM DESIGN

Mileys is a geo-located collecting game that integrates location-based information, augmented reality, and virtual characters. It is aimed to make drives more interesting, to use trips in the car to create a stronger bond between parents driving in the front seat and child passengers in the back seat, to encourage safe and ecological driving, and to connect child passengers with their environment (outward focus), instead of only their entertainment devices (inward focus). By creating a driving-based collection game, children will look forward to the next milestone, instead of getting bored and wanting the drive to end. Through the game, they can acquire a sense of distance, location, and geography.

The game centers around virtual characters called Mileys, which are conceptualized at certain geographic locations. They are not immediately visible, but only through the application using a technique called augmented reality (AR). Using the Mileys application, users can look through a live digital video stream and detect the creatures when they encounter them.

According to the game narrative, Mileys like to ride in cars but can't access those car rides directly. Instead, they rely on children to pick them up and take them with them on short rides. Moreover, while Mileys enjoy the ride, they are also sensitive creatures and get sick when the ride is too bumpy (unsafe / non-eco-friendly) or accelerates too fast.

Children must search for hidden Mileys using a combination Radar and AR application, and once they pick up a Miley, they are responsible to carry it for as long as possible, negotiating with the driver to drive more carefully if necessary. If the creatures get too "sick", they leave the car and children get points for any distance and time which they carried the Miley. The Miley then waits in the dropped off location for the next child – or the same child on a repeat trip – to pick it up again.

The main game play contains the following stages:

3.1 Plant

Parents can plant Mileys using the mobile interface (see Figure 1) or using a web mapping interface available on any computer (see Figure 2).

3.2 Find

Children seek Mileys, using a first-person radar interface ("magic torch"). The radar needs to be pointed in a certain direction to uncover Mileys in that direction (see Figure 3). Children need to instruct the driver where to go in order to locate Mileys, thus expected to become active participants in the navigation process. The radar's distance levels are set to 250m, 1km, and 10km to accommodate for in-car driving speed. Through this interface, children can acquire a sense of distance and relative position in accordance to evolving traffic conditions.

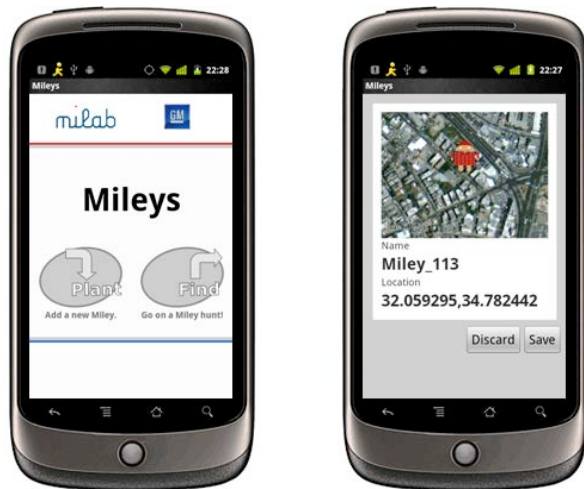


Figure 1. Left: Home screen – choosing "Plant" (parent) or "Find" (child) mode. Right: "Plant" mode – finalizing plant.



Figure 2. Planting Mileys using the web mapping interface.



Figure 3. "Find" mode – first-person radar view.

3.3 Capture

Using the AR interface, children can capture Mileys (see Figure 4). Their goal is to insert the Miley into the green circle at the center of the screen. The use of AR is expected to focus children's attention towards the surrounding landscape.



Figure 4. "Capture" mode – Miley seen via the AR interface.

3.4 Carry

Once a Miley is captured, the child needs to keep it steady. At first, it has a health level of 100%. The health level decreases every time "bumpiness" is encountered. This is indicated by a number combined with an emotionally charged "paling" of the creature (see Figure 5). Each second and each meter the Miley is carried counts for points. In order to maintain Mileys' health, the child might need to negotiate with the driver to ensure steady driving, thus promoting safe and ecological driving.



Figure 5. "Carry" mode. Left: A Miley with full health points. Right: A Miley having lost health points.

3.5 Drop

When the Miley runs out of health, it is "dropped", and a notification stating the time and distance it was carried appears on the screen (see Figure 6). Once the Miley has been dropped off, it becomes available in the same drop location to additional children, or the same child on repeated trips. At this point, the character appears in full color again, to indicate the Miley regained its health.



Figure 6. "Drop" mode – notifying the child about the time and distance a Miley was carried.

4. USER STUDY

In order to evaluate the functionality of the system and how it is received by users, we conducted a 6-week long field study. Families representing the target demographics were asked to use Mileys during their regular car rides. We interviewed each family at the beginning and at the end of the study, as well as collected usage data through a log file.

4.1 Method

4.1.1 Participants

Six families with children 10-12 years old (3 males, 3 females) participated in the study. All families resided in Tel-Aviv – a large metropolitan area at the center of Israel, and their children attended the same school. They were recruited through personal acquaintance with one of the authors. The families volunteered to participate in the study and received a small prize in exchange for their participation. Demographic characteristics of each family are presented in Table 2.

All the families had at least one computer at home and several mobile devices, such as laptops or tablets. All the children had their own mobile phone, often a smart phone, and were familiar with using mobile applications.

4.1.2 Procedure

The study, conducted during August and September 2012, consisted of the following three steps:

- 1) *Initial interview* – A member of the research team visited each family in their home. He supplied them with a Samsung Galaxy S mobile device on which Mileys was installed, demonstrated how to use the application and conducted a semi-structured interview regarding the family's current in-car habits and preferences. Questions were answered by both children and parents.

- 2) *Free use of Mileys* – Each family used Mileys for a period of six weeks.
- 3) *Final interview* – A member of the research team visited each family in their home, collected the mobile device on which Mileys was installed, and conducted a semi-structured interview regarding the family's experiences while using Mileys. Questions were answered by both children and parents.

Both initial and final interviews were transcribed and then independently analyzed by two judges (the second and third authors), who identified the emerging common themes. In addition, log data from the mobile devices was retrieved in order to analyze actual usage patterns.

Table 2. Demographic characteristics of families participating in the study. Age and gender (Male or Female) of children who were the main users of Mileys are highlighted in bold font

	Age of Children	Parents' Occupation
Family 1	11(F) , 16, 19	Project manager (Internet) Manager (Pharmaceuticals)
Family 2	4, 11(F) , 13	Pilot Curator
Family 3	5, 10(M)	Graphic designer Hair stylist
Family 4	5, 12(M)	Musician Real-estate agent
Family 5	3, 9, 11(M)	Programmer Curator
Family 6	11(F) , 21	Lawyer Artist

4.2. Results

4.2.1 Initial Interview

During the initial interview, participants were asked regarding their current in-car experience and technology usage habits. Most families indicated that joint car drives usually occur during weekends and holidays, when the family goes on trips or visits relatives living outside the city. In regard to the typical atmosphere inside the car, several families indicated that tensions often arise.

Father 5: *"There are three brothers sitting in the back seat, the minute they get in the car they start fighting: I'm in front, I'm allowed to do this, I'm allowed to do that".*

In addition, children can get bored during drives, complain about their duration and inquire when they would end. Due to their repetitive nature, one family even turned the child's complaints into a game.

Child 6: *"We get bored [during drives]. We also play the complaints game".*

Mother 6: *"It usually begins when she asks when we'll be arriving, I'm tired, I'm bored, and then everyone has to complain about something".*

Child 6: *"You have to come up with funny complaints".*

In regard to ways of passing the time during long drives, some families talk with each other about general topics or about the surrounding landscape.

Mother 5: *"We talk a lot with the children during drives. Everyday stuff but also about what we're seeing around us... Here's the Gilboa mountain".*

However, children are not always interested in the various locations pointed out by their parents.

Child 6: *"They tell me – look over there, there's a mountain, there's a road".*

Mother 6: *"Vey interesting. But nothing gets in your head".*

Child 6: *"I don't find it interesting".*

Mother 6: *"We tell her all sorts of stories, sometimes biblical stories when we arrive at relevant locations. Do you find this boring?"*

Child 6: *"A little".*

In regard to using digital devices inside the car, two families mentioned playing games on an iPad, although this could lead to the child experiencing nausea. Most families only use music players, listening to music or recorded stories, either as a group or individually.

Father 3: *"We have a 32 gigabyte memory card in the car, so everybody creates their own playlist, and every time someone else is the d.j. Listening to music is the main thing we do in the car".*

Mother 6: *"She listens to music on her iPhone".*

Child 6: *"With headphones".*

Different families adopt different approaches regarding technology use in the car. In some families each member is focused on his or her own screen, whereas other families intentionally try to avoid this situation.

Father 1: *"Due to the screens, the tendency is to disconnect, put on headphones and that's it".*

Father 3: *"We don't encourage having everyone focused on their own screen".*

When asked whether they would like to change their current driving experience, several parents wished for greater interaction and connection between family members, something they feel got lost as their children grew older.

Father 1: *"I prefer there would be something more familial, something we all do together. Many years ago, my wife used to bring a bible to the car, read a short story, and we would argue about it, which was very nice, because there are several interpretations for everything".*

Father 5: *"We used to listen to a CD with stories we remember from our childhood... But we do it less and less, both because we are getting old and because the [children] form their own opinions regarding what they want to do".*

Lastly, we asked participants whether children play a part in navigation to desired destinations. Only one family mentioned that the son is in charge of the navigation system, but several parents wished their children would play a more active part.

Father 3: *"When we need to use GPS for places we don't know, my son is in charge of navigation, and then we talk about what is*

going on around us. The GPS is sophisticated, so [my son] tells me when I'm above the speed limit or when to change lanes".

Mother 6: *"I sometimes think about the option that she would navigate, but it doesn't happen... I want her to decide when to turn, where to turn, learning how to use a map, learning to recognize locations on the map. I think it's important".*

In sum, family drives can be a source of tension and boredom, but also an opportunity for family members to share music and stories with one another. Parents wish joint drives would be used to strengthen the bond between family members and for teaching children how to navigate.

4.2.2 Log Analysis

Participants' actions within the application were recorded into a log file. Log files were analyzed to better understand usage patterns. Due to technical problems, we could only retrieve 5 out of the 6 log files. First, we examined the action of planting Mileys. Parents wishing to plant Mileys for their children could do so by using either the mobile application or the web mapping interface. In total, 260 Mileys were planted during the study, 27 (10.38%) through the mobile application and the rest through the web mapping interface. Even though all families resided in a single city, Mileys were planted at various locations around the country, covering approximately a third of the country's area. This widespread deployment indicates an intention to use the game during long trips.

Next, we examined capturing and carrying activities (see Table 3). On average, each family captured 6.6 Mileys, which were carried for an average of 65.64 seconds and 71.64 meters. This distance is relatively short, implying that children used the application while walking and not just during car drives. This type of use was confirmed during the final interview.

Lastly, we examined the specific dates on which the application was used, and discovered that each family played on two different occasions, usually on weekends or national holidays, when families typically go on trips together.

In sum, the log analysis indicates the preferred use for Mileys is leisure use during long trips outside the city, not everyday use. In addition, the relatively short carrying time and distance per Miley indicate the system was used during walks, not only during drives.

Table 3. Number of Mileys captured, time and distance carried for each family

	No. of Mileys Captured	Avg. Time per Miley	Avg. Distance per Miley
Family 1	6	95.83s	48.33m
Family 2	5	14.80s	64.40m
Family 3	13	78.23s	61.77m
Family 5	5	31.00s	100.80m
Family 6	4	86.25s	111.25m

4.2.3 Final Interview

During the final interview, participants were asked regarding their experiences with Mileys, usage frequency, and whether they have suggestions for improving the application. We present their answers according to the stages of the game.

4.2.3.1 Plant

During this stage, parents plant Mileys, to be later found by their children during family car rides. Our log analysis revealed that hundreds of Mileys were planted at various locations around the country, mostly through the web mapping interface. Parents described the planting action as easy and quick to perform.

Father 2: *"It was very simple, easily done. When we traveled north, in 2-3 minutes I planted Mileys all along the route."*

4.2.3.2 Find

During this stage, children seek Mileys, using a first-person radar interface. Children in the current study found it difficult to understand the interface, and thus were unable to instruct the driver where to go in order to find Mileys. In that regard, children did not take as active part in the navigation process as we hoped they would.

Child 5: *"I found it a bit difficult to understand this stage"*.

Father 2: *"There was no connection to the space beyond capturing or holding Mileys, no 'maybe it's after the traffic light' and things like that. But since I planted the Mileys and knew where they're supposed to be, I gave clues"*.

4.2.3.3 Capture

During this stage, children capture Mileys, using the AR interface. Children in the current study seemed to like this stage very much, even though they were not always successful in capturing the Miley.

Child 5: *"This was the nicest stage. I sat next to my brother and we both tried to catch the Miley"*.

Father 5: *"This was something that kept them both busy and was fun for them to talk about"*.

Child 6: *"I saw [the Miley] spinning there, but I couldn't catch it"*.

4.2.3.4 Carry

During this stage, children need to keep the captured Miley steady, otherwise its health level decreases. Participants in the current study liked this stage, however, they complained that the sensitivity level was too high. As a result, children could only carry a Miley for short periods of time before it was dropped off. This caused frustration in some cases, because the children seemed to compete amongst themselves who could carry the Mileys longer.

Father 3: *"It's a nice idea, but the required skill is too delicate. Every little move decreased points, the [Mileys] died very quickly... it created frustration"*.

Child 3: *"It was too sensitive"*.

Child 6: *"This is my favorite stage... I once put the device on a table, and the next day I told kids in my class that I earned over 8000 points. I win!"*

It is interesting to note that adjusting the system's sensitivity was considered the only option for allowing children to hold on to the

Mileys longer. Neither children nor parents suggested driving more slowly or smoothly as an option for achieving the same goal.

In sum, the "Find" stage was revealed to be too difficult for children, who did not understand how to operate the radar-like interface. As a result, they did not play an active role in the navigation process during family car rides. Most children preferred the "Capture" stage, even though they were not always successful in capturing the Mileys. The "Carry" stage was also considered enjoyable, however, children and parents alike found it to be over sensitive, leading to rapid drop off of any captured Miley. A competition emerged between the children, even though the game was originally designed for personal use. Moreover, the system was revealed as susceptible to misuse, allowing players to accumulate points even when they are not moving or holding the device.

4.2.3.5 Usage Frequency

In accordance with our log analysis, most families reported using Mileys only few times during the study. We identified several barriers which prevented a more frequent use of Mileys: technical problems, forgetfulness, car-sickness, dissipation of interest and excitement over time. The main barrier for use was technical problems encountered by several families.

Child 5: *"There were GPS reception problems"*.

Father 5: *"Several times we received a notification that the application was stuck and needs to be restarted"*.

Child 5: *"Many times it got stuck, which was a bit of a bummer"*.

Father 5: *"I think the fact that it got stuck slightly lowered his motivation"*.

In contrast, two families did not encounter any problems. All families used the same type of mobile device provided by the authors (Samsung Galaxy S), so this variance in errors frequency is intriguing. Mileys is heavily dependant upon GPS reception, so we believe most problems were a result of poor reception. Different families attempted to use Mileys at different locations and times of day, which could account for the variance in errors frequency.

The second barrier for using Mileys was simply forgetting to use it.

Mother 6: *"We traveled up north with my sister's daughters in the car, we were already in the car, but she didn't show them [Mileys]"*.

Child 6: *"Because I forgot! We meant to show them"*.

The third barrier for using Mileys was experiencing sickness while playing the game. This is not a unique problem for Mileys, but rather a general problem with car-sickness. Participants reported the same problem during the initial interview, when referring to in-car iPad use.

Child 6: *"It made me feel a bit sick, so that's why I stopped [using Mileys]"*.

The last barrier for using Mileys was dissipation of interest and excitement with the game over time.

Father 3: *"When it was new, it was an experience to try it out, but fairly quickly he [stopped using Mileys]"*.

4.2.3.6 Suggestions for Improvement

We asked participants how they would improve Mileys, and noticed an interesting difference between children and parents' perspectives. Children were focused on improving the game experience, allowing users to personalize the Miley character, advance to additional levels within the game or interact with other players.

Child 2: *"I wish you could design your character, choose what color it's going to be, which clothes it would wear. Also, for every amount of time you hold a Miley, you could earn points and then buy clothes with those points or something like that".*

Child 6: *"I have an idea – if you catch 10 Mileys, you get to discover something".*

Child 3: *"Add a chat, communication between us. If someone is nearby... it would say: There's an additional Mileys player located 900 meters from you. Would you like to contact him?"*

Unlike children, parents were not interested in the specifics of the game. Instead, they wished they could utilize Mileys for strengthening the bond between family members, and for educating their children about meaningful events that occurred at the locations they are currently passing through.

Mother 6: *"As a parent, I'm not thrilled that they sit in front of a screen all day long. So when we're finally out of the house, what interest do I have to use this activity?... What do I, as a parent, expect would happen? Maybe some sort of riddle you need to answer".*

Father 2: *"It should integrate information about the current location, for instance if we're driving north and we planted a Miley at Golani junction, it should say something about Golani".*

Father 2: *"It's a personal game... also the screen is not very big, so it disconnects the player from the rest of the group, he's very engaged in the screen... In that aspect, I don't think [Mileys] brings families together. Perhaps if you add sounds that others can hear as well... so those who aren't looking at the screen would also be informed and could do something together".*

As one can remember, similar sentiment was expressed by parents during the initial interview, before the families began using Mileys.

5. DISCUSSION

In this paper we presented Mileys – a novel in-car game that integrates location-based information, augmented reality and virtual characters. It is aimed to make drives more interesting, to use trips in the car to create a stronger bond between family members, to encourage safe and ecological driving, and to connect child passengers with their environment, instead of only their entertainment devices. We evaluated Mileys in a six-week long field study, during which families with children 10-12 years old freely experimented with the game. Based on our findings, we identified several key challenges for location-based in-car game design for children.

5.1 Different Expectations

An interesting difference emerged between children and parents regarding their desired in-car experience. Most children get bored during long rides, as they find little interest in navigation or the surrounding landscape, despite their parents' efforts to point out

interesting locations along the route. Children prefer to spend their time in the car listening to music or playing enjoyable games. In contrast, parents view family trips as an opportunity for strengthening the bond between family members, and for educating their children about history and geography. In accordance with these perspectives, when asked to suggest improvements for Mileys, children focused on improving the game experience, whereas parents focused on enabling group interactions and dispensing location-specific information. In-car game designers must reconcile these differences with their design, by presenting educational content in an enjoyable manner. In future versions of Mileys, we would enable parents to add text to each Miley they plant. The text could refer to various historical and geographical facts related to the current location, and would be presented in the form of a quiz. This way parents could educate their children in a fun and engaging manner. For example, upon arriving to an historic location and capturing the Miley planted there, a text bubble would appear on the screen, asking the child questions regarding the events transpired at this location. A correct answer would be rewarded with accessories for the Miley character or additional health points. Parents would now have a suitable context for further elaboration. Alternatively, the text accompanying each Miley could refer to personal events. For example, upon arriving to an historic location and capturing the Miley planted there, a text bubble would appear on the screen, telling a story about how the grandparents first met there 50 years ago. Parents would now have a suitable context for further elaboration on the family's history.

5.2 Undesired Detachment

Parents in our study were concerned that introducing an in-car game might direct the child's focus towards the screen, away from the rest of the family and the environment. In order to prevent this undesired detachment, in-car game designers should promote interactions, both with elements in the environment and with other family members. We believe AR is a promising tool for promoting interactions with the environment. As for promoting interactions with other family members, we plan on adding audio signals that can be heard by all occupants of the car, perhaps over the car's entertainment system, thus enabling parents to track their child's progress through the various stages of the game. Adding gaming elements that call for offline discussions with the driver or other passengers would also help achieve this goal.

5.3 Short Interaction Span

Children in our study failed to capture Mileys sometimes, because they weren't fast enough. Location-based games connect specific actions in the game to specific locations, so they become available only when the player enters a pre-defined radius. However, location-based in-car interactions are usually short, due to the constantly changing location of the moving vehicle. The short span of interaction might prevent the player from performing a certain action in the game. In order to overcome this challenge, game designers should define adaptable radiuses that automatically increase with speed, thus ensuring sufficient interaction time even in high speed. Alternatively, the gaming experience could be based on a number of different location scales (for example: 100m, 1km, 10km) that occur concurrently. In any case, designers should allow players to complete the game even if a certain action could not be performed. In future versions of Mileys, we plan on implementing adaptable detection radiuses, as

well as simplify the interface. The radar-like interface of the "find" stage would be replaced by a simpler 4-arrows interface, and the interface of the "capture" stage would be changed, so that capturing a Miley character would be performed with a touch on the screen, instead of inserting it into a circle. Hopefully, these changes would allow children to complete the respective actions more rapidly.

5.4 Poor GPS Reception

Location-based games are often dependent upon GPS reception, which tends to fluctuate according to various factors beyond the designer's control. For instance: low sensitivity of the GPS sensor in the mobile device, large physical obstacles casting a shadow and even poor weather conditions can all decrease GPS reception, and consequently interfere with game flow. Indeed, participants in our study encountered technical problems due to poor GPS reception, and these problems discouraged further play with Mileys. Game designers could compensate for poor reception by maintaining the last known location until a current location could be detected. Alternatively, they could offer a location-free activity until GPS reception is restored. In future versions of Mileys, we plan on adding new activities with the Miley characters, which would automatically be initiated whenever GPS connection is lost.

5.5 Motion Sickness

Several children in our study complained about car-sickness, which prevented them from playing with Mileys. Car-sickness, or motion sickness in general, is a fairly common phenomenon, with higher susceptibility among women and children 7-12 years old [7]. Motion sickness is believed to be a result of sensory conflicts, for instance when the vestibular and somatosensory systems are signaling that the person is sitting still, while the visual system is signaling movement [7]. In-car game designers for children should make sure their design does not aggravate existing susceptibilities to motion sickness, perhaps by using accelerometer data to adapt the on-screen elements of the game to the current driving conditions. Furthermore, the game should call for short screen intervals, intertwined between long non-screen intervals. This type of design is also useful for countering the challenge of undesired detachment. We plan on reducing the required screen time in future versions of Mileys.

These challenges emphasize the distinctive nature of in-car game design for children. HCI researchers and practitioners must overcome these challenges, an endeavor to which we hoped to contribute with the development and research of Mileys.

6. CONCLUSION

This paper presented Mileys – a game aimed to make car rides more interesting for child passengers, strengthen the bond between family members, encourage safe driving, and connect children with their environment. Mileys integrates location-based information, augmented reality and virtual characters. A user study designed to evaluate the game revealed that hundreds of Miley characters were planted at various locations around the country, covering approximately a third of the country's area. Furthermore, the game was mostly played on weekends and holidays. These results indicate the preferred use for an in-car game is leisure use during long trips. Based on findings from the user study, we identified and suggested solutions for five challenges of in-car game design for children: 1) Different

expectations by parents and children regarding the desired in-car experience; 2) Undesired detachment from the surrounding landscape and other family members; 3) Short interaction span for location-based activities; 4) Poor GPS reception disrupting game flow; 5) Motion sickness while using electronic devices inside a car.

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