A Cooperative In-Car Game for Heterogeneous Players

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ABSTRACT
Car rides are often perceived as dull by the passengers, especially children. Therefore, we aim to introduce a system fostering a collaborative and communicative experience in this environment. This paper presents the design for a game played together by all car-occupants, including the driver, according to their abilities and capacities. A fully implemented prototype of our system called *nICE: nice In-Car Experience* is evaluated under real world conditions in a user study with five families using a qualitative approach.

Keywords
multimodal user interfaces, collaborative games, heterogeneous players

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: Miscellaneous

1. INTRODUCTION
Innovation in today's automobile industry is mostly driven by electronics and software [11]. Traditionally these innovations lie within the areas of safety, efficiency and driver assistance, which are mainly focused on the driver's needs. There are efforts in making the drive more comfortable for other occupants: Contemporary premium cars are offered with sophisticated rear entertainment systems, e.g. BMW's system includes a flat screen and audio jacks for DVD, TV, music and internet access for each occupant in the back of the car [2]. Fellow passengers mostly experience the ride based on the comfort of the car and the amusement offered by the entertainment system. We found that passengers mostly pass time on their own rather than interacting or communicating with the other travellers (Section 4.2.3).

In cooperation with automobile manufacturer BMW, we aim to create a more unique and fulfilling experience for all vehicle occupants by introducing our concept for a collaborative in-car experience, called *nICE: nice In-Car Experience*. We propose a multimodal, collaborative game, played on two multi-touch tablet devices by the passengers in the front and back seat. The driver may decide to assist them verbally or with simple interactions if they think that the traffic situation allows for it.

During our game all passengers 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 minigames. The driver is involved in the game through the audio clues or information obtained from the other passengers. He can participate by joining the discussion between the passengers or via control elements on the steering wheel, which gives the other players an edge in the current game. Our goal was to examine the user experience of our collaborative in-car game and the suitability of our concept for creating a more engaging journey. Although we did not evaluate traffic safety explicitly we incorporated many recommendations of the European Commission for safe and efficient in-vehicle information and communication systems [5] (Section 3.1).

The contributions of this paper are twofold: Firstly, we propose collaborative gaming as an addition to the established array of entertainment options, provided by automobile systems, and present our concept for a collaborative game in Section 3. Selected pieces of related work are discussed in Section 2.

Secondly, we implemented a game that aims to facilitate cooperation between users of different abilities and capabilities. We evaluate this game using a qualitative, approach centered around user interviews in Section 4. We also gathered quantitative feedback via a semantic differential based on the standardized AttrakDiff questionnaire [6] and questions about users' psychological needs [12]. However, the statistical power of these results is low, due to the small number of participants. Nevertheless, we report these figures as we believe they can indicate overall tendencies when viewed together with our qualitative results. We have selected a challenging user group for our evaluation: Families with children aged six to ten. This allows us to assess how well our collaborative experience for all vehicle occupants performs for users with a large gap in age and ability. We discuss future work and give a conclusion in Section 5.

2. RELATED WORK
In this section we describe related work that either presents ways to foster interaction with others while driving or introduces games designed to be played specifically by car occupants.

Hocman is an on board communcation computer for motorcyclists [4]. It senses other Hocmans, triggers proximity alerts and auto-

AutomotiveUI'11, November 29-December 2, 2011, Salzburg, Austria

matically exchanges preset websites. They transfer messages, such as ads or contact information, and enable people to get in touch afterwards, thus sparking social interaction with passengers of other vehicles. Hocman is aimed at interconnecting passengers of different vehicles during brief encounters while our system fosters interaction and engagement between passengers of one vehicle over extended periods of time.

Soundpryer is an on board computer for motorists [10]. It senses the proximity of other Soundpryers and streams music either to or from those other vehicles. Like Hocman it is aimed at interconnecting drivers of different vehicles, this time using the medium of music. Both systems demonstrate an interest on behalf of the driver to interact with other persons while driving.

CommuterNews is a news guessing game for commuting drivers [13]. It considers the attention span of drivers by allowing them to pause and unpause interactions with the system at their convenience. It also uses audio output to relay information to the driver instead of just displaying text. These considerations are similar to the way that nICE is interacting with the driver. Our system does not require immediate driver attention at any time and mostly uses audio hints or information from the passengers instead of visual clues.

Backseat Games is an augmented reality game for car rides [3]. It is designed to entertain children during long journeys via an interactive narrative told with augmented images of roadside objects. Similar to our system it acknowledges the need to entertain passengers but it forgoes the option to involve the children's parents in the experience.

Verbal games are being played by many families to pass time on long car journeys. There are many examples for verbal games, e.g. "I spy" [14], "20 questions" [15] or "Geography" [1]. Most of these games are purely verbal and require no material for playing. As with our concept, these games foster communication and interaction between car passengers. Direct adaption with digital media might be possible but we are unsure about the benefits this might add. However, traditional games that require some equipment can benefit from a digital adaption. One example is the game "pictionary" that requires players to guess what the other player is drawing. We have implemented this game in our prototype and have received positive feedback from users about it (Section 4.2.5). Our implementation allows players to enjoy this classic game regardless of the seating arrangement and without having to worry about pen and paper.

The work discussed above draws upon similar motivations as nICE, e.g. increasing communication during car journeys and providing new forms of entertainment for the driver or passengers. However, to our knowledge no attempt to foster togetherness between all car occupants - regardless of age, skills or role - has been made so far. We are deliberately placing the focus on the occupants of one car and are therefore developing our concept without vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) components. Future work might focus on this aspect to achieve a collaborative cross-car experience instead of an in-car experience.

3. CONCEPT

Together with our cooperation partner, the car manufacturer BMW, we have defined the following goals for our system:

- Foster the sense of connectedness between all vehicle occupants
- Integrate all players into the game, each according to their respective abilities
- Ensure suitability for both long and short journeys
- Design the system with safety in mind

As mentioned in Section 1 we designed a collaborative game to meet these criteria. We present the design in the following section and briefly discuss the safety considerations in Section 3.1. We have chosen families with children aged six to ten years. Therefore our design not only has to consider the different levels of attention that the driver and passengers can allocate to the game, but also the gap in ability between the parents and their children. For our initial design we are assuming one child, located in the back seat playing the game together with two adults as co-driver and driver.

3.1 Safety Considerations

Throughout our design we roughly followed the recommendations of the European Commission for safe and efficient in-vehicle information and communication systems [5]. Arguably, the most important of these for us are "The system does not distract or visually entertain the driver" and "The allocation of driver attention while interacting with system displays and controls remains compatible with the attentional demand of the driving situation". Our concept acknowledges these design goals by mostly using audio feedback for the driver. This is done directly by the game and indirectly via conversation with the other vehicle occupants. We also do not require driver input in a time critical fashion. Furthermore, direct driver interaction with our system is limited to single button presses. Overall, driver participation is beneficial but not required throughout the game. This allows the drivers to decide for themselves which traffic situations are suited for participation and how intensely they wish to be engaged in the game.

Safety is an integral part of any system designed to be used during car travel. However, we did not explicitly test traffic safety either on the road or in a driving simulator so far. Several informal tests with staff of BMW research and development, who are trained in driving vehicles with experimental systems, were performed to examine if the level of distraction is acceptable for extended real world tests. They classified the amount of distraction as acceptable for our purposes. During the evaluation, all real world tests have also been performed with BWM staff who are trained in handling vehicles with experimental systems. We believe that we have adequately addressed safety during development of our prototype by relying on the combination of following safety guidelines and using experienced BMW staff for our real world tests. After the concept for the game has matured, safety needs to be addressed in more detail and with a more formal approach. Our intent was to fixate our rapidly changing game concept through a qualitative evaluation before shifting the focus from the game experience to safety implications.

3.2 Design

A game played in a car has to be designed differently compared to a traditional game played at home. The controls must be usable while the car is moving, meaning that they must be of a bigger size. Also, some passengers feel dizzy when reading in a moving vehicle, which implies that it should be kept to a minimum.

To interact with nICE the co-driver and child both use multi-touch tablet devices. The driver interacts via the steering wheel buttons.

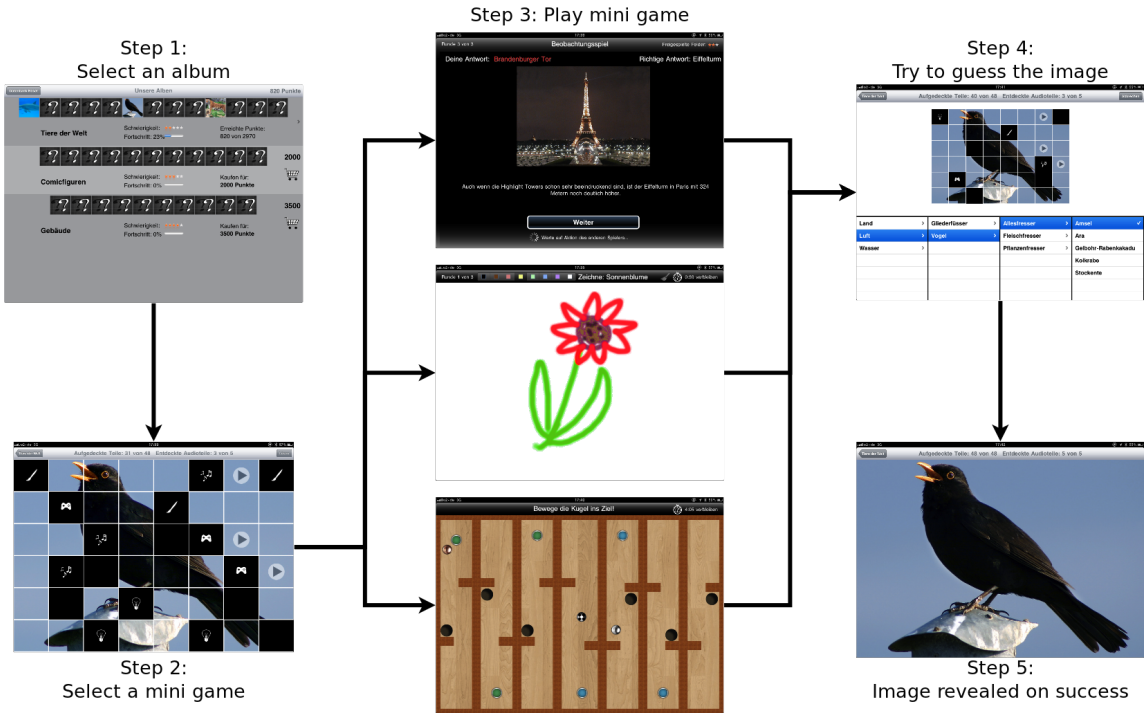

Figure 1: Gameflow experienced by the players

The game conceptually consists of albums, which contain images on a certain topic. For example, one can think of an album with animal or comic figure pictures. At first, every image is covered with several square tiles hiding the content of the image. The goal of the game is to completely uncover images by correctly guessing their content. We call this part of the game the metagame since it serves as the overarching goal for a longer period of time, typically ten to 20 minutes. To actually uncover parts of the image, players have to solve different minigames. A minigame is a short-term game which is played collaboratively by the occupants. Up to three tiles can be uncovered depending on how well the players performed in the minigame. We decided to structure the game in this fashion for various reasons: We addressed the heterogeneity and accounted for the differing tastes of our target audience by introducing several conceptually different minigames with varying content and game mechanics. This also contributes to keep the game dynamic and varied. Lastly, different minigames offer an easy extension point for further development. Since we envisioned players using the game intermittently, the end of a minigame also provides a natural break in gameflow that allows a pause. The metagame provides the overarching motivation for a medium length timespan. Players may choose from the following minigames:

The music quiz is about solving questions related to a song. The game plays this song aloud for all car occupants. Questions asked by the game depend on the skill-level of the players, e.g. the child has to name the movie title of a theme song, but the parents have to name the main actor. The players are presented with four possible answers. Once during the three rounds of the game the driver may use a 50:50 joker, which removes two wrong answers. This joker is activated by pressing a steering wheel button. The players are allowed to help each other on the questions or to communicate with the driver and get his advice. To remove additional tiles from the metagame, the participants can play a karaoke game in which either the child or the co-driver sings a song that is to be guessed by the other players. After the song has been guessed the players can continue singing together to encourage the community spirit among passengers.

The observation game challenges players to guess the location of a nearby sight on a map. Subsequently, they are tasked with answering questions related to that sight. As in the music quiz the game consists of three rounds and the driver can give the other players an edge by using the 50:50 joker. Again, players are encouraged to communicate with each other, ideally creating a discussing between all car passengers.

The labyrinth game is played by the co-driver and the child. Each player controls a ball through a labyrinth by tilting the tablet. To complete the game the players have to work together. One player has to position their ball on a switch, which opens a door for the other player. Players are able to see the position of the other player's ball on the map, thus increasing the sense of collaboration.

The drawing game is similar to the well-known game pictionary. On a rotating basis the co-driver and child draw a term on their tablet, which is simultaneously displayed on the other device. The other player has to guess which term is being drawn. The driver assumes the role of referee and confirms a right answer by pressing a button on the steering wheel. In order to do that, the current term is displayed in the head-up display, which is only viewable by the driver. The drawing game is not a competitive game. It encourages a mutual experience by provoking communication between the players.

After a minigame is finished a number of tiles on the grid are exposed based on the players' performance in this minigame. Some tiles also contain an audio hint. These hints give additional information and allow the driver to join in guessing the displayed picture. Audio hints are represented by a certain overlay. Players can start the audio hint each time they tap these tiles. After each minigame the co-driver and child have the possibility to enter their guess for the picture. If a wrong answer is selected, the last few uncovered tiles are lost and have to be earned again. If the answer given is correct, the picture is revealed completely and added to the players' collection.

As stated in Section 3.1 drivers are involved through auditory clues and freely decide their level of engagement with the game. These clues can either be provided by the game directly or through conversation with other passengers. Direct audio output by the game is currently provided at two points: The songs played in the music game and the audio hints of the metagame. The conversational aspect is currently strongest in the quiz style games (observation game and music game) and is present in the painting game and metagame to a lesser degree. Direct interaction with the game through steering wheel buttons is present through the jokers in the quiz style games. The driver also confirms correct guesses in the painting game by pressing a steering wheel button. This game is also the only game that provides visual feedback for the driver in the HUD. Driver interaction is lowest in the labyrinth game. They may only indirectly help the other players by keeping the car steady.

Figure 1 illustrates the sequence of game elements that the players experience. Step 2 and 4 comprise the metagame, minigames are played at step 3. During the course of the game players will iterate through steps 2 to 4 multiple times before reaching step 5 and beginning anew from step 1. A short video with impressions from our evaluation and a comprehensive walkthrough are available at `http://www.youtube.com/watch?v=Nyr_aInEojU` and `http://www.youtube.com/watch?v=Qz7BYC7EqZU`

4. EVALUATION

This section details the results of a user study with 14 participants from five families[1] who evaluated a fully implemented prototype of our concept. We validate our assumptions about the users' usual experience during car rides through their feedback. Our observations during a test drive with the game, conducted under real world conditions, are presented along with user feedback about the experience they had. We also evaluate our system with the help of a two part questionnaire after this test drive. The results are presented in Section 4.2 before they are discussed in Section 4.3.

As part of our design and development process we also conducted several small scale evaluations with users that were not part of our main target audience (families with children). We summarize the results of one such study, conducted after we had completed our initial design, in Section 4.1. Within that section we focus on the contrasting feedback obtained from players with homogeneous and inhomogeneous backgrounds, as it was the case in the preliminary and final evaluation respectively.The main questions we addressed throughout our evaluations were:

- Which experiences prevail for occupants during normal car rides? Is there a need for our system?
- How did the interaction with our prototype influence the travel experience?
- Did we succeed in creating a fun and collaborative experience for all car occupants?
- How is the driver affected by our game? What is their subjective assessment of their distraction level?

4.1 Pre-study

Before the actual user study with our prototype implementation we conducted a pre-study to evaluate the first draft of our design. Since we did not have an implementation available at this stage, we used different mock-ups to visualize the components of our game. The metagame (image guessing) was represented by pictures covered with sticky notes which were removed after a successful minigame playthrough. The minigames were simulated on iPads since it was important for us to test how users would interact with those devices in a car. The question based mini-games (music quiz and observation game) were visualized via static images and we used a non-collaborative version of the labyrinth game as a stand-in. We did not test the drawing game in this evaluation. All scoring and game-logic was performed by two researchers who accompanied the participants during their journey on the same route as in the later user study (Section 4.2.2). The users in this experiment were one female and two male computer science students aged 23 to 25.

A rich discussion and cooperation emerged around the questions of our quizzes. The players tried to involve the driver in answering every question but it quickly became apparent that he could not follow the flow of the game while driving in the city. Therefore the other players resorted to asking the driver only when they could not answer a question on their own. We also noticed that the driver looked at the co-driver's iPad during red light stops and was tempted to do so while driving. This cumulated in the driver missing the right turn for the highway although being assisted by a GPS system. Thus a different route had to be chosen.

In general we had the impression that the study participants felt compelled to solve as many pictures as possible. This resulted in a heated atmosphere which might have been caused by our methodology. We did not observe this kind of pressure during our later study. The music quiz introduced a welcome break with even the driver being able to actively participate easily. Especially the karaoke part introduced an opportunity for a bonding experience. After the backseat passenger started singing, the co-driver joined in. They continued with this activity even after they were awarded with the points. Overall, we received positive feedback from our users at this stage, particularly about the music game. Further feedback of this study's participants is reported in in Section 4.4 where we contrast it with feedback obtained from families during the evaluation of our prototype.

4.2 Evaluation of the Prototype

In evaluating our system we use a qualitative rather than a quantitative approach. Many of the characteristics of a qualitative approach, as described by McDavid et al. [9], are beneficial to an evaluation with our target audience: Using natural language throughout the entire process allows us to better involve kids that do not have sufficient reading and writing skills for abstract questions. Furthermore, a qualitative approach is focused on understanding the subjective lived experiences of our users, which is one of the main evaluation goals. We therefore use an inductive approach in data gathering, interpretation and reporting of the results.

[1]One of the drivers did not participate in the interviews and questionnaires because of further appointments.

4.2.1 Participants

As explained in Section 3 we defined families with children as the main target group for our evaluation. We recruited five families with children aged between six and nine years from the employees of BMW research and development. This means that at least one of the parents in each family had a technical background. Drivers were 40 to 46 years old and were all working as engineers. As mentioned at the beginning of this chapter, only four drivers participated in the interviews and questionnaires after the test drive. Co-drivers were aged 37 to 43 and had more diverse backgrounds: We interviewed an accountant, a business economist, a digital media designer, a mathematician and a housewife. Four co-drivers reported previous experience with multi-touch devices, one did not. Since the content of our music game required a certain level of familiarity with kids' entertainment programmes in Germany, it is worth noting that four co-drivers grew up in Germany while one immigrated from an Asian country. All five kids grew up in Germany. All of our drivers had special training in handling vehicles with experimental equipment.

4.2.2 Procedure and technical setup

During this study we evaluated a fully implemented prototype of our system. The game was running on two iPads which communicated with each other via a wireless connection. An iPhone was used to simulate information which would be displayed in the driver's HUD. Pressing a steering wheel button was mocked up by tapping the iPhone screen. This encompasses all direct interactions described in Section 3.2. We placed the iPhone over the revmeter in the car's dashboard where it was both easily readable and reachable by the driver, although they still had to remove one hand from the steering wheel to interact with the game.

We used this agenda for our user study:

1. Interview of each family on their previous car travel experiences and how often they would conduct long distance car trips together (Section 4.2.3). Other questions cover the usual seating arrangement and how the family members pass time together or individually.

2. Introduce our system and show the family how to start and play each game on the iPads provided by us.

3. The parents and one of their children embark on a 25 minute trip, equally divided between driving in the city and on a motorway. They are accompanied by one researcher who serves as an observer and provides technical support if necessary. All test drives are conducted in a vehicle provided by BMW, not the families' own cars. The observations made during this test drive are reported in Section 4.2.4.

4. A second round of interviews focusing on the experiences the participants made during the field test and their opinion of our system. The feedback gathered during the interview is detailed in Section 4.2.5.

5. The parents complete a questionnaire which includes a semantic differential, based on the AttrakDiff question set [6, 8]. The second part of the questionnaire covers questions pertaining to psychological needs as described by Hassenzahl et al. [7]. These needs are based on the ten psychological needs for satisfying events identified by Sheldon et al. [12]. More details about the design of the questionnaire is given in Section 4.2.6.

4.2.3 Previous experiences

Every family reported that they were going on a car journey of at least one hour once or more often each month. One family conducted such a journey almost every week. During a longer drive the kids often get bored very quickly and become impatient. The parents usually respond to this by making use of the car's entertainment system to distract the kids by providing them with movies to watch or audio dramas to listen to. Some kids also listen to music on their own or play video games. The interaction with other family members was reported to be minimal during consumption of these electronic media. If the car occupants are playing games together they usually do so without the participation of the driver. The kids either play among themselves or with the co-driver, letting the driver focus on driving.

When prompted for incommoding factors to a car journey the children again mentioned the boredom of being confined to the car. Parents usually stated that impatient behaviour from the children adversely contributed to the atmosphere in the car. Sometimes minor arguments between the children erupt out of this which increases the stress levels of all car occupants. Therefore, the parents we interviewed welcomed opportunities to keep the children engaged during a car journey as they otherwise usually prove to be uneventful. We asked the study participants to describe a memorable experience they had during a car journey. They struggled to come up with an answer, often citing negative experiences such as traffic jams. Positive experiences that were mentioned included impressive scenery or, in the case of some children, the first time they had watched a movie in a car. None of the study participants described a situation where they interacted with other car occupants as being especially memorable. This might be due to the communication patterns that the families described during our interview: Conversations are usually carried between the driver and co-driver or among the backseat passengers. There often are times with no conversations at all when every occupant is occupied with their own thoughts.

We also asked the families about their gaming habits. All of the children were familiar with video games but also enjoyed playing traditional board and card games with their parents. The frequency with which games were played by the families varied from daily to almost never. Parents from two families expressed the wish to spend more time playing games with their children, but this was often hindered by a busy work schedule. When explicitly asked, the participants responded positively to the idea of playing together during car journeys, however some families expressed safety concerns if the driver was to be involved.

4.2.4 Observations during the car journeys

This section details the observations of the researcher present in the car during the test drives. His role during the experiment was largely a passive one, observing the flow of the game and providing assistance in case of technical difficulties. It was purely the families choice which minigames they wanted to play as no instructions were given by the researcher.

We observed that the driver involvement was varying among different families: Three out of five drivers where very frequently involved by their passengers and were actively engaged in almost all games, e.g. by offering advice on quiz questions or giving hints for the correct solution of the painting game. One driver even used to assume the role of singer during the karaoke game since the song happened to be one of his favorites. The flip side of these high levels of involvement was a higher level of distraction as these

drivers tended to take a look at the co-driver's iPad - sometimes even while the vehicle was moving. For the other two families the driver involvement was reduced: They were asked for their input on fewer questions and they did not give as many hints for the painting game. These drivers would often offer their assistance by leveraging the 50:50 joker, indicating an interest from their side to be involved in the game. While driver involvement varied, there were no cases where there was none at all. The audio hints provided with the metagame along descriptions from the passengers also helped to involve the drivers in solving this visual puzzle. For example: One family always stated their guesses for which animal was displayed and the driver either confirmed them or made alternative suggestions based on the information he obtained from the audio hints. The lowest overall involvement was during the labyrinth game where the driver could only indirectly influence the outcome by keeping the vehicle steady. One driver used this moment to swerve the car around the lane, triggering motion sickness in his child. It was one of our concerns that especially children could become nauseous during the game. However, apart from this one case, this did not happen. The multi-touch devices proved to be a viable choice for playing a game during a car ride. We observed no major usability problems apart from users inadvertently missing an UI-element on rare occasions, which could be easily mitigated by increasing their size. Figure 2 shows a child interacting with the system during our experiment.

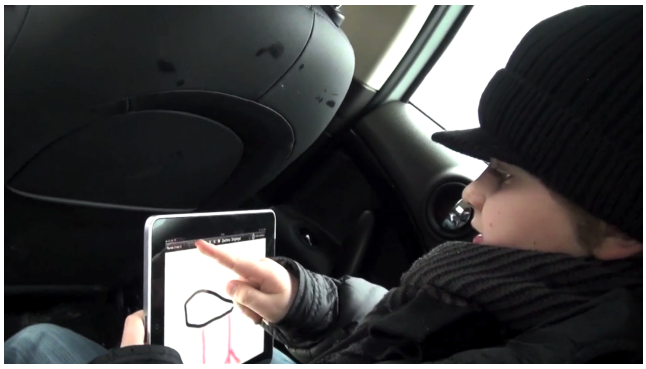

Figure 2: Child interacting with the game

Other interesting observations could be made about the suitability of the content and games for players with different abilities and backgrounds. As described in Section 4.2.1, most of our participants grew up in Germany. The researches observed that one Asian family recognized very few of the songs and TV shows referenced in the music quiz. They seemed frustrated by this and played this game only once, preferring more culturally neutral games such as the painting game or the labyrinth game. Another way in which families would adapt their gaming behaviour based on the players' abilities became apparent in the family with the youngest child: Since it was only six years old reading was still quite hard. The family adapted by slightly modifying their behaviour during the painting game: The co-driver would cover her ears while the driver was telling the child which picture should be drawn. Sometimes the driver would also simplify the term to adjust the level of difficulty. The family had no problems with playing the labyrinth game, but other games were not played since they required a higher level of reading competence.

4.2.5 User Feedback

Directly after the test-drive we interviewed the families again to collect their spontaneous opinions and reactions to our game. Children were asked simplified versions of the adults' questions.

All families rated the test drive as more entertaining than a normal journey. *"Time passes very quickly."*, *"We were not bored at any given time."* or *"It was really entertaining."* were some of the spontaneous comments offered by the adults. The children shared this view (*"It was really nice."*) and when asked to rate our game with a school-grade consistently assigned the best possible grade. When asked to describe the differences between the journey they just had and a normal car ride, the study participants gave feedback such as: *"We were engrossed by the game."*, *"I did not hear 'Are we there yet?' even once."*, *"I liked that [my child] was involved in everything."* and *"We talked more with each other."*

Although we observed differing levels of driver involvement as described in Section 4.2.4, our participants concluded that they felt that everyone was involved in playing the game. The drivers themselves shared this view, citing their contributions as support in finding the right answer during the music or observation games or as giving hints to the correct solution to the painting game. There was no clear consensus among the drivers as to whether or not they felt distracted by the game. Two drivers said they were not distracted very much, while the other two drivers responded that they were tempted to look at the co-driver's iPad screen: *"Yes, [I felt] distracted. You want to help the others, so you will look at the co-driver's iPad now and then. [...] However, normally you will refrain from more challenging driving maneuvers in such situations."* One driver described the level of distraction as similar to making a call with a hands-free headset.

The participants of our study agreed that the most suitable situation for playing our game would be on the motorway (*"[Being the driver,] I could join in once we were on the motorway. [Playing the game] was not reasonably possible in the city."* and *"[Motion sickness] was dependent on the road, especially when it was curvy"*), especially during non challenging situations (*"Whenever not much is going on, for example during traffic jams"*). One family also said they would like to play the game when travelling on well known routes: *"[The game is suited] for well known routes when one already knows all of the road and environment."* The limitations that were placed on prolonged usage of our game were mostly the need for regular breaks from game play due to driver exhaustion: *"I could imagine playing that game for half an hour to fourtyfive minutes, but on a longer trip the children will definitely also watch [a movie] for two hours without any interaction."* The passengers themselves also concluded that they could not imagine playing the game continuously for multiple hours and concluded they would rather play the game intermittently.

The two best rated minigames were the painting game and the labyrinth game. Four out of five families preferred the painting game: *"I thought the painting game was really good, only the difficulty should be adjustable for the childrens' age."* and *"You don't have to think too much and can use more of your imagination."* are two representative comments. Two families also named the labyrinth game as their favourite, but were not able to give a reason for that. Problems cited with the other minigames were, that two families felt that the questions in the music game were too difficult both for the child and parent: *"Some of the questions were almost unsolvable."* The observation game was regarded worse by the participants because it was difficult for them to locate the position of sights on the map and they then had subsequent usability difficulties with marking the location on the map. Additionally, all of the children disliked the karaoke part of the music game because they found the task confusing and did not know the songs. Regarding

further improvements, the possibility to seamlessly pause and resume the game was named by two families. Three families would like the difficulty to be more adaptive to the age of their children. Two drivers wished for more involvement during the game. The example that both cited was the option to see the image created by the other players during the painting game.

Overall the families rated our game as very entertaining and said they would like to use it again in the future. Some of them even continued playing on their way home, on their own initiative, after the experiment had ended. One user summarized her opinion as *"The perfect thing [to do] in a car."*

4.2.6 Questionnaire results

Adult participants were asked to complete a two part questionnaire after the test-drive. While the sample size is not large enough to discern statistical significance we nevertheless believe that we can measure tendencies through the questionnaire. The first part consisted of a semantic differential where users had to choose between adjective pairs on a seven-point scale. These adjective pairs were based on a subset of the AttrakDiff questionnaire [6] for measuring perceived hedonic quality (HQ) and pragmatic quality (PQ). The score for pragmatic quality measures the perceived suitability of "an interactive product to manipulate the environment", i.e. it is an indicator for the perceived usability in our case. The score for measuring the hedonic quality can be subdivided into a score for identity (HQ-I) and stimulation (HQ-S). Whereas identity describes what kind of identity is communicated by a product, the stimulation measurement describes how a product is promoting the growth of an individuals skills and knowledge [8]. Additionally, we use two adjective pairs to measure overall attractiveness (ATT). Figure 3 shows the averaged answers to each word pair.

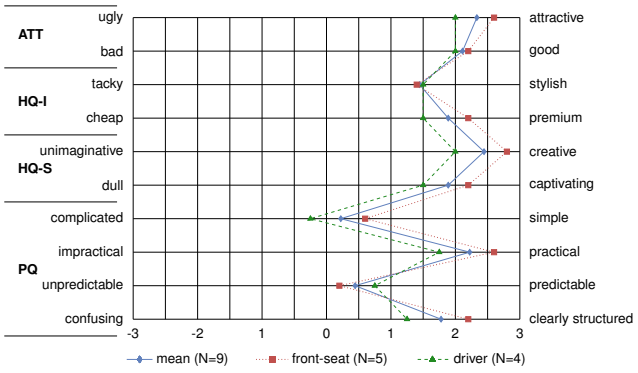

Figure 3: Semantic Differential based on a shortened AttrakDiff questionnaire. Questions marked with "ATT" refer to a product's overall attractiveness, "HQ-I" to its hedonic quality based on identity, "HQ-S" to hedonic quality provided through stimulation and the "PQ" group describes the product's pragmatic quality.

The fulfillment of users' psychological needs during an experience plays an important role in creating a satisfying event through a product [7]. Sheldon et al. [12] identified ten psychological needs for satisfying events and gave candidate questions for how to measure their fulfilment. To keep the questionnaire short we again chose a subset of these questions for the second part of our questionnaire. Figure 4 shows these questions which users answered on a five point Likert-type scale.

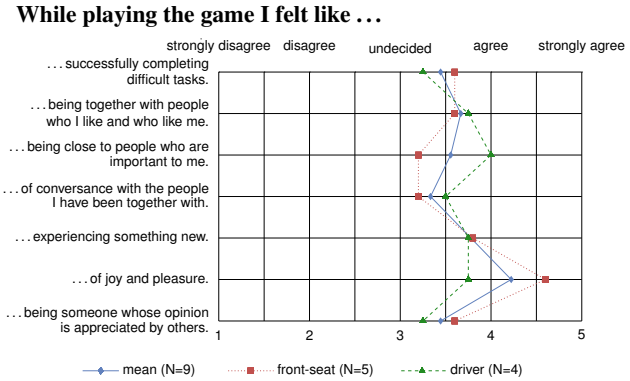

Figure 4: Fulfillment of psychological needs as rated by the study participants. The first question pertains to a sense of competence, questions two to four are concerned with the participants' sense of relatedness, questions five and six address their sense of pleasure and stimulation while the last question gauges their sense of popularity and influence.

4.3 Discussion of the study results

Overall, we think that the background factors described in Section 4.2.3 present a great opportunity for collaborative casual gaming. By designing our game to be played during a car journey we hope to mitigate some of the negative aspects of the journey while simultaneously increasing the level of interaction and engagement between the car occupants. The situation described by the families outlines the potential for increased communication built upon an activity which each family member enjoys but often cannot find the time to engage in: playing a game together.

Our observations during the test drives (Section 4.2.4) together with the participants' feedback in Section 4.2.5 lead us to conclude that we succeeded in creating a fun experience for the families. The results of the AttrakDiff questionnaire (Figure 3) and the questions about psychological needs (Figure 4) also seem to show that users had fun while playing our game and found it to be stimulating (high values in the category HQ-S). Users' verbal feedback also speaks of an increased sense of togetherness and heightened communication. Their answers in the questions about psychological needs, especially those related to togetherness (questions two to four) indicate that they are a bit more undecided on this issue. Overall, it is unclear at this point how much of the reported effects can be attributed to the novelty of playing a game in the car since most families have never done anything similar before. Nevertheless we are encouraged by the initial results and hope to clarify the long-term effects during further studies. Two out of four drivers reported feeling distracted while using our prototype. However, the fact that many drivers were tempted to look at the co-driver's iPad could indicate that they hoped to be involved in the game to a higher degree. As mentioned in Section 4.2.5 two out of four drivers stated that they wanted to be involved more. Changes to the design along this line need to be carefully balanced, necessitating formal safety testing to proceed.

4.4 Comparison with the pre-study

The music and knowledge quiz both were regarded very positively by users in the pre-study. The music quiz, especially the karaoke section, was judged as the best minigame in our test which contradicts the feedback given by families, especially the children. The

level of challenge posed by the quiz questions on the music and observation game was welcomed by the users in our first study since they valued the resulting discussions. The children in our later test felt more compelled to solve every question on their own and became quickly frustrated when they gave a wrong answer. They felt a sense of competition with the co-driver even though the game did not keep score of individual performance. The families' experiences with the karaoke game were also different: We were not sufficiently successful in choosing songs that were known to both the parents and children so that a similar experience as in the preliminary evaluation could be achieved. In addition the children often were not yet acquainted with the concept of karaoke. These results demonstrate that concepts which work very well for gamers of similar abilities and knowledge levels do not necessarily transfer to a game played by users with an ability gap.

The participants in our preliminary study regarded the labyrinth game rather indifferently: They said that it was fun to play and the additional challenge from doing so inside a moving vehicle was welcome, but it did not stand out from the other minigames. The families in our next study regarded the labyrinth game much more positive, some played it almost exclusively. We believe that the added factor of collaboration, present during the latter experiment, significantly increased users' motivation to play the game. By directly observing the other player's movements as well as their own, users could compare their relative level of competence. This added a small element of competition to the game, a wish often expressed in user's feedback. This game also performs well for players with similar age and experience as we observed during other tests. This example shows how introducing a collaborative element, while leaving the underlying game principle unchanged, elicited a more positive response from users in our experiments.

5. CONCLUSIONS AND FUTURE WORK

We have presented a concept for a collaborative game which is designed to be played by all occupants of a car during their journey. A test of the implementation under real world conditions has provided promising results. However, we found that the users were very focused on the game, neglecting the roadside environment. Our attempt to draw the players' attention towards points of interest located nearby through the observation game were not successful. We think that shifting the focus from the game itself outward to the journey could lead to an increased feeling of togetherness for the car occupants. Therefore, we would like to further examine the integration of the roadside environment into the game. The fixed difficulty level and player constellation were a point for improvement that was raised by most of our users. Future work should therefore aim at more flexibility in terms of the number of players as well as the level of challenge presented to each of them.

In general, users liked our approach to foster an engaging collaborative experience, but the evaluation was performed with a narrow target audience over a short period of time. While these results were important to gauge the initial reception of our system by potential users, we would like to widen the scope for the future. This means both a broader, more diverse audience and an evaluation that encompasses a longer timespan in order to supplement our results with statistically valid data. In preparation for a more comprehensive user study, the system should undergo additional safety testing first. This will allow us to address the issue of driver distraction that was raised in our evaluation. For this reason we have been limited to BWM employees with a special driver's training which has limited our pool of available study participants so far.

6. ACKNOWLEDGEMENTS

This work was created during the course of the Software Engineering Elite Graduate Programme. We would like to thank BMW research and development for making this project possible and their kind support.

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