# Keep your eyes on the road and your finger on the trigger - Designing for mixed focus of attention in a mobile game for brief encounters

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**Abstract.** In this paper we present an initial user feedback study of the Road Rager prototype. Road Rager is a mixed reality game, designed to enable passengers in different cars to play against each other during an encounter in traffic. We are concerned with how to design a game which balances the player's focus of attention between traffic and the computer interfaces, to provide a game which is comprehensive, interesting and challenging during a very limited lifetime. The study shows that a tangible user interface enables the player to handle the interaction in the game while watching for cars in the vicinity. Further, the users found multiplayer gaming during brief encounters exciting. However, the study also showed that minimalism is critical to the design. The gestures should preferably be indexical rather than symbolic, and elaborate forms of identification as a condition for manipulative success should be avoided. Finally, tangible user interfaces also allow a type of gaming where players only focus on the computers' interface, which suppresses the experience of combining traffic inetraction with computer interaction.

## 1 Introduction

In recent years, a number of studies have focused on the exploration of tangible user interfaces to create augmented reality games [5, 16, 18, 19, 21, 23, 24]. These studies are concerned with the possibilities for graspable user interfaces to create experiences that mix real life with virtual life. We suggest that this form of interaction is especially suited to multiplayer gaming, which only occurs during brief social encounters in mobile situations. Therefore, we have designed a game prototype, called "the Road Rager", which includes a tangible user interface. Gaming is enabled by wireless ad hoc networking technology between car passengers as they convene within a limited range.

The choice of a tangible user interface was motivated by the high relative speed of the players, which makes an encounter very brief. Occasionally, such an encounter last no longer than a couple of seconds. We wanted to generate a user interface that can be handled and experienced while watching for cars in the vicinity during this limited time. Screen-centric interaction risks causing the player to focus on the computer, rather than look out the windows, and thus spoils the specific benefits of a

mixed reality game. Consequently, a key challenge concerns the possibility to enable and balance the player's engagement between computer and traffic, when the time available for identification and interaction with the opponent is very restricted. In this paper we present an initial user feed back study of the game. The game was tested by a total of twelve children in three different cars, during three sessions, circling around a route to generate encounters.

Travelling along a road conveys a continuous flow of impressions and new situations where changing scenes, the sense of motion and contingent encounters provide a very special experience [1]. It can be seen as a sequential experience, resembling a dramatic play of space and motion, i.e. the highway experience. Still, passengers look for other opportunities to pass the time. They might read, talk or play mobile games. But mobile games, and car embedded entertainment systems, are often portable versions of classic computer games where the focus is on a screen [2]. Thus, gaming becomes a complete alternative to the highway experience. This form of traditional computer game obscures the highway experience, rather than exploiting the journey for fun, exploration, play and creativity. The possibility of incorporating different aspects of mobility to create immersive experiences is therefore still a promise not yet realised [3]. Our hypothesis is that a game could be particularly engaging if it included the vivid and dynamic mobile context. Contingent traffic encounters such as rapid frontal meetings, protracted overtaking or gatherings, e.g. traffic jams or queues at red lights constitute an essential part of the experience of travelling along a road [4]. These meetings can be used to create fun and compelling mobile games and can add to the gaming experience [5].

The purpose of the study is twofold. First, we will investigate the general experience of a concept, which draws on brief social encounters in a game. Here, our initial user feedback study shows positive reactions towards the idea. Second, we will investigate how to afford interaction in use-contexts where the lifetime of the mixed reality is very limited. We will, in the following, discuss how the interaction could be supported by the design of the user interface, the tasks and the reward structures. Our study shows that the challenge of the use-context itself is so difficult that minimalism is critical. Furthermore, the study suggests that neither support nor rewards for real world focus are needed for the players to maintain a visual focus of attention on the traffic. Instead a blended experience between traffic and the computer occurs very much because the players accept and like the experience that playing in the same space allows.

The research is of interest for the design of pervasive and mobile mixed reality applications that include tangible user interfaces. Tangible user interfaces (TUI) were originally developed to close a "gap" between parallel, but related, activities in a real and a virtual world [6]. The problem of providing a proper mixture of virtuality and reality in mixed reality applications has been raised by Trevisan, Gemo et al [7]. They argue that the multiple sources of information available, and the two worlds of interaction, demand that the users make "choices about what to attend to and when." They suggest that we move beyond the first design agenda of creating a seamless, invisible fit where things are blended together, to see mixed reality as consisting of discrete elements between which users alternate. The issue is to design the boundaries to allow alternation but preclude improper mixture. This study contributes a better understanding of how to design such boundaries in situations with very limited "lifetimes" [8].

Enabling interaction in temporally restricted situations is an emergent issue when mobile technologies become embedded into "truly mobile" use contexts where people interact with objects and co-located people as they move [9, 10].

## 2 Related work

This paper is related to research in the area of *proximity based games, augmented reality* and *tangible interfaces*. A number of academic research projects make use of proximity between players as a resource in a computer generated game, e.g. Treasure [11], Pirates! [12], PacMan Must Die and Earth Defenders [13]. This possibility is also exploited by the industry, e.g. the commercially available Botfighters from It's Alive [14]. These games are played via the interface of a mobile device using traditional graphical user interfaces, with buttons and stylus as interaction mechanisms. Thus, the players have to choose between looking at their surroundings and engaging in the game. "Can you see me now?" and Bystander [15] are mixed reality games where online participants compete or collaborate with mobile participants on the street. Both games are played via a traditional screen-based GUI. The participants can also collaborate by communicating via a real-time audio channel while moving through the city streets. In this way the participants themselves have the means to co-focus on the game and the physical world.

There are several projects that propose the use of augmented reality (AR) to enhance existing games [16]. Augmented reality is generally defined as "any mixture of real and virtual environments", but often specifically refers to "see through" displays [17]. ARQuake [18] and Human Pacman [19] are examples that allow the user to walk around within an outdoor game-space. ARQuake seeks to map the traditional game Quake onto a physical arena. Human Pacman integrated fantasy features of traditional computer entertainment with physical and social aspects. The games superimpose graphics directly upon the real world using a see-through head-mounted display. The accuracy of the overlaying is a critical problem [20]. Calibration errors and lags in the system easily contribute to a mismatch between the two worlds, especially when the viewpoint or the object is moving. This problem would be even more apparent in a dynamic and mobile situation such as travelling in a car, and especially in an application where both the viewpoint and the object are moving in relation to each other. Furthermore, a user study of the Human Pacman system revealed that a majority of the players found the system too bulky and cumbersome.

Tangible User Interfaces (TUI) allow more embodied interaction with the computer. Ping Pong Plus was designed by Hiroshi Ishii et al already in 1999 as a form of "digitally-augmented cooperative play." Table tennis has been augmented with an interactive surface, which incorporates sensing, sound and projection technologies. The players can focus either on real objects, such as the ball, or look at the augmented effects when it hits the table [21]. There are a number of projects exploring the field of tangible interfaces and games [22, 23, 24]. However, these games are stationary, and are dependent on a pre-set infrastructure, such as projectors or tabletops.

## 3 The Road Rager

The game is developed for a PDA equipped with WLAN capability. Gaming activity is accomplished through peer-to-peer wireless ad hoc networking, allowing connection between the devices without any further infrastructure. It is aware of the player's aiming direction by means of a digital compass, and the geographical position through a GPS-receiver. A Basic stamp II microcontroller controls LEDs and external buttons on the tangible interface (figure 1).

**Figure 1** Clutcher, PDA and Bluetooth GPS

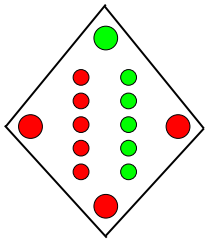

**Figure 2** LEDs on top of Clutcher

The devices automatically initiate a game-event when two players are in close proximity, i.e. within approximately 100 to 200 meters of each other, depending on the surrounding environment. When the game begins the player takes on the role of a character with magic powers. The player's goal is to acquire power in preparation for the yearly witchcraft convention. Power is measured in stars and frogs, which are gained or lost when duelling with other players. A duel is automatically launched when two players are within wireless range. The event ends when one player becomes enchanted, or if they move out of range. If a player charms her opponent, the objects she possesses are traded for more powerful ones, e.g. frogs are exchanged for stars. If the connection is broken they receive stars or frogs dependent on their results up to that point.

It is important to account for traffic safety when designing a game for use in a moving vehicle. This game is therefore intended for passengers in the back seat who are not engaged in the manoeuvring of the car. Still, the game could affect driving if badly designed. Therefore, we have tried to minimize the player's urge to request assistance of the driver. More specifically, there is no support in the game for predicting or making the traffic encounter happen more frequently by changed travel routes or driving styles. Further, it is essential that the player should feel comfortable with the embodied interaction provided by the game, even though they are buckled-up and remain so. However, the discussion in this particular paper is concerned with how the players experience the game per se.

### 3.1 Game interaction

The concept depends on the players' possibilities to look out the windows of the car, and spot the opponents, in conjunction with playing a computer game. Since the time for interaction is limited, these activities have to be tightly integrated. Therefore, we chose a tangible interface. The assumption is that the players can concentrate on spot-

ting each other and act instantly without withdrawing their visual attention from the traffic.

The tangible interface, called the *Clutcher*, is equipped with fourteen LEDs and a button. Four of the LEDs, hereafter referred to as "locator LEDs", are placed in each corner (figure 2) to inform the player of the direction of the opponent. Ten smaller LEDs are placed in two rows. They are sequentially turned on and off to indicate the amount of magic power the player possesses. One of the rows indicates the player's own power and the other that of the opponent. The button is for changing virtual tools (see section 3.2).

We have chosen to use the screen of a PDA as an interface to provide additional information to further stimulate the imagination of the player, and to provide the player with feedback on the results of the duels. The information is not critical for the gameplay during an encounter, but is intended to be observed and experienced in between game-events.

### 3.2 Balancing the focus of attention through design

The Road Rager concept is specifically designed to enable what we refer to as a *blended* focus of attention. Blended attention occurs when the players engage in gameplay and interact with the computer in various ways, e.g. to make gestures or listen to sounds, at the same time as they are looking out of the windscreen. We have provided for blended attention through the specific design of the user interface as well as the choice of game characteristics such as tasks and the rewards for fulfilling them.

According to Trevisan, Gemo et al [7] designers can influence what users look at and interact with by controlling attention through the design of the synchronization and integration of the user interface. Synchronisation refers to the ways in which an event controlled by the system is temporally unfolded. The system can present media, demand input or request a task either simultaneously or in a sequence. Integration refers to choices of what types of interaction will occur, e.g. how the user will receive feedback and how the media are distributed to output devices. Furthermore, integration refers to where the media is presented vis-a-vis the user's attention, i.e. in the central or peripheral context of the focus of attention.

The users' attention can also be influenced through the design of game characteristics such as the way the game is *explored* or how it should be *manipulated* [25]. Exploration refers to the players' experience of moving and travelling within the game. In this case, the players' view from the windscreen becomes integrated with that experience, and especially the ways in which they look at surrounding vehicles to *identify* contestants. Manipulation refers to tasks provided in the game, where players actively change the state of "*temporal, spatial, causal and functional relations and properties.*" According to Eskelinen, a game can do without interesting narratives or other forms of exploration, but it must always have manipulative challenges to be a game. Finally, a specific focus of attention can be afforded by the reward structure in a game.

Three tools (the *Magic Wand*, the *Sludge Thrower* and the *Electro Squeezer)* were designed, which in various ways combine user interfaces, tasks and rewards, in order to investigate the possibilities of enabling and experiencing blended attention.

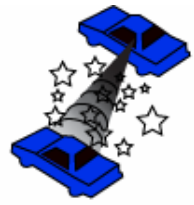

**Fig. 3** Casting spells

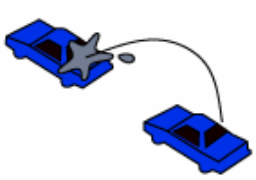

**Fig. 4** Throwing sludge

**Fig. 5** Triggering electric shocks

The *Magic Wand* (figure 3) strongly requires that the player be engaged in blended attention to be successful. The player has one chance to cast a spell, while very close to the opponent, to get a high score. Therefore the player needs to know exactly who she is contending with. The identification is made possible by the "locator LEDs" on the Clutcher (see figure 1), which give clues as to the direction of the opponent. When the adversary is located, i.e. when she has decided who in that direction she is contesting with, the player visually focuses on that car and makes the gesture when they are very close. It is the most rewarding of the tools if the player identifies the opponent and waits until they are close, which is approximately 20 meters, to cast the spell, to further favour visual identification. If the spell is cast directly after peer connection the gain is only minimal.

The tool affords a sequential order of tasks to be successful. The player must first identify the opponent and then wait until the other car is really close before engaging in manipulation. The user interface is designed to allow a visual focus on the traffic both during identification and manipulation. The player can simultaneously look at traffic and the LEDs on Clutcher as a form of sight, when trying to identify the opponent. The player can continue to look at traffic, while making gestures in a circular pattern to cast a spell, when engaging in game manipulation. Further, sounds are played while the Clutcher is moved, and when the spell is properly cast.

The *Electro Squeezer* is designed with minimal demands on the player to blend attention, and identify the opponent, in order to be successful (figure 5). It only requires that she recognize that a contestant is within wireless range, which is conveyed by a specific sound, before starting to manipulate. There are no limits as to how many times the player can score but the rewards are small. It sends out fictive electric shocks and plays a specific sound if the Clutcher is squeezed. Thus, there are no demands for either simultaneous or sequential ordering of tasks.

The *Sludge Thrower* (figure 4) is designed to require interaction with traffic to a degree somewhere in between that of the previous tools. It enables the player to throw virtual sludge at the opponent and score points if it hits. Similarly to the Magic Wand, the process requires that identification and manipulation be carried out sequentially. The design to support identification is also the same. However, the tools have different manipulative tasks. The Sludge Thrower only requires that the Clutcher be aimed towards the contestant to be successful. Further, the integration of modes of interaction is similar to that of the Magic Wand. The player can throw magic sludge, in the same way as if throwing a smaller real object, to score points. The gesture recognition registers when the player moves the Clutcher forward and downward. The player will hear a sound indicating that something is flying through the air for approximately two seconds and then a sound indicating hit or miss. This interaction could be done simul-

taneously with looking out of the windows. There are no limits as to how many times the player can score.

## 4 Method and setting

Road Rager is intended for chance encounters on the road against unacquainted players. These meetings may take place anywhere along the road network. However, in order to ensure encounters with other players as well as to be able to observe the gameplay, the field trial was restricted to a preset circular route where the subjects used the prototype during a limited period of time. Each lap took about ten minutes. Fourteen children tested the game. Half of them were eight years old and half of them were ten years old. The two age groups played the game separately for approximately thirty minutes. Three cars drove simultaneously along the route with two to three children in each car. Each vehicle was equipped with a game device and the children within a car took turns playing the game. Before the test, all the participants received an explanation of the game and practiced the techniques of the tools. One or two researchers, sitting in the front seats, rode along in the car during the test. This set-up created a number of events where the Road Rager concept was experienced.

The activities were video recorded, and a loosely structured interview was carried out after the gameplay, in order to pursue an analysis of the test subjects' visible behaviors and to increase our understanding of their experiences. Video recorders are increasingly used to collect data during HCI evaluations [26]. However, as of yet there are no common standards for transcribing video recordings similar to the code schemes in conversation analysis [27]. Consequently, we have developed a coding scheme that accounts for the details of the children's activities of relevance for this study. Unfortunately, because of certain technical problems, the test cases turn out to be fewer than originally intended, which resulted in recorded material from a total of seven players. These video recordings have been transcribed and coded. We studied facial expressions, general appearance, visual focus of attention, handling of device and spontaneous comments during the game session. Careful analysis of visible behavior increases the possibility of understanding their appreciation and skills.

The test situation was unrealistic in certain ways. The children encountered the same cars several times since the route was circled during the test session. The children soon learnt what they where searching for, which otherwise would be unlikely. However, it also made it possible for us to study the difference in gameplay between acquainted and unacquainted encounters. The game is constructed to promote different strategies. This is hard to test during such a short period of time, and would instead require that the players played the game for an extended period of time. The same applies when studying the experience and fun of the gameplay in the long run. Regardless, this test provides input of importance for future design both concerning the experience of the gameplay and the design of user interfaces for short lived mixed reality applications.

## 5 Analysis

We are concerned with how players direct their attention between the visually available traffic situation and the device, in actual gaming, as well as how the gameplay is experienced. First, we will analyse how the focus of attention is pursued for each of the tools. Second, we will analyse the focus of attention during other phases of gaming, such as when the player are out of wireless range and during peer connect. The players' comments in the excerpt and the interviews are translated from Swedish.

By player we mean the child who is in control of the Clutcher, and by partner we mean another child riding in the back seat of the same car. The opponent is the child participating in the test who is riding in an encountered car. Finally, a game-event is defined as the period during which two devices are connected during a meeting.

### 5.1 Differences between tools

The way the players directed their attention varied between the three tools. For each tool we have structured the material accordingly. First, we discuss whether the players understood how the tool was supposed to be used. Second, we analyse the players' focus of attention during gameplay. Finally, we present the players' experience of using the tool.

**Casting magic spells.** The Magic Wand is designed to require a high degree of visual focus on traffic, in conjunction with a focus on the computer interface. It was difficult for the players to meet these demands as discussed with reference to the following two excerpts:

**Table 1.** (P=player, F=partner, R=Researcher)

| Time | Sound | Hand movement | Visual focus | Comments |
|---|---|---|---|---|
| 10:22 | Magic Wand | | F looks out P looks at device | |
| 10:26 | Connect | | F looks out P looks at device | P: aaa |
| 10:27 | | P lifts the device | P looks out F looks at device | F: aaa |
| 10:28 | | P moves the Clutcher in a circle | P and F look out through the windscreen | |
| 10:29 | Spell | | | |
| 10:30 | | F points at a passing car they meet in opposite lane | P looks down at the screen. F looks out through the left window. P quickly glances at F's hand then back to screen | F: there! |
| 10:31 | | | P and F look at screen | P: where? |

In the excerpt above the player already has the Magic Wand activated when the game-event begins (10:26). Both the player and the partner quickly look down at the screen when they hear the connect sound. They both look out through the windscreen and the player immediately makes the gesture to cast a spell (10:28). Then he directly focuses on the screen. Not even his partner's pointing towards the opponent drags his attention away from the computer (10:30). He seems confused, which is further supported by his comment "where?" while he is looking at the display and refuses to look where his partner is pointing. Thus, the player casts the spell almost immediately after the

connection sound is heard with very limited attempts to identify the opponent. He doesn't perform the tasks of identification and manipulation in a sequence as intended in the design, but rather almost juxtaposes them. However, during manipulation the player simultaneously maintains visual focus out through the windscreen while interacting with the computer, i.e. listening to the audio feedback and interacting with gestures. Thus, here the player blends his focus of attention.

**Table 2.** (P=player, F1 and F2 =partners , R=Researcher)

| Time | Sound | Hand movement | Visual focus | Comments |
|---|---|---|---|---|
| 05:51 | Connect | | P looks at PDA screen | |
| 05:52 | Spell + hit | P moves the Clutcher in a circle | P looks at the PDA screen | P: help! |
| 05:55 | | | F1 looks down at the PDA screen | F2: was it someone who hit us? |
| 05:58 | Electro Squeezer hit | | P and F1 look at the PDA screen | F1: try and take this one |

The excerpt in table 2 presents another type of gameplay when the Magic Wand is used. The player has the tool activated before they come into wireless range, as in the previous example. When the connect sound is heard (05:51) the player looks at the screen on the PDA and immediately makes the gesture to cast a spell (05:52). As in the previous case, the player goes straight into manipulation, casting the spell immediately after the connection sound is heard. They display limited attempts to identify the opponent and no delay for the cars to come close enough to get a high score. Then both the player and the partner look at the PDA screen (05:55). One of the partners asks whether they got hit (05.55) and they then get into a discussion on what tool to use next (05.58). However, in contrast to the other case, the player pays no visual attention to the traffic when engaged in manipulation, and solely focuses on the computer screen. Thus the player displays what we term *device centric attention*. This type of gaming did not fit with our intention to require visual focus on the traffic.

There could be several explanations to the juxtaposition of identification and manipulation as well the device centric attention. It seems like the players understood the concept of the wand in general and how it depended on identifying the opponent and delaying the casting of the spell until they were really close. This general understanding of the concept is visible in other parts of the field test. On one occasion a partner says: "I think we see them ... be prepared...I think we should take the Sludge Thrower, it has better distance than the Magic Wand." Thus, we need to look at other possible explanations. The demand for interaction could be set too high given the brief duration of gameplay. Or they could just have become too excited to wait until the contestant was identified and was close enough. However, the concept of a Magic Wand cannot be ruled out altogether since its proper use is difficult to evaluate during such a short field test.

It is not surprising that the players commented in the interviews that they did not like the Magic Wand. Some children had thought that the Magic Wand was going to be the most fun and useful tool before the test. Erik said they had thought the wand would be the best tool "…because you died immediately.*"* However, they soon changed their minds because, as Bill says, "…it didn't turn out that way. You earned more by choosing a less effective tool."

**Throwing sludge.** The Sludge Thrower provides information on the direction to the opponent and requires that a gesture be made in that direction to be successful. Thus, it provides valuable information on where to look for the adversary, but does not require that they know exactly where in that direction the car is in order to score.

The majority of the children quickly got the idea of how to handle the Sludge Thrower. Most of them practiced throwing sludge when there were no opponents around. There were two ways of using of the tool where the players balanced their focus of attention in different ways. First we will look at gameplay where the player successfully engages in interaction with blended attention.

**Table 3.** (P=player, F=partner, R=Researcher)

| Time | Sound | Hand movement | Visual focus | Comments |
|---|---|---|---|---|
| 23:17 | Connect | | P and F look at the screen | F: now |
| 23:22 | | P casts an unsuccessful magic spell | P looks at the screen. F looks out thought the windows and searches actively for opponent. | F: I think they are behind us |
| 23:25 | | P casts a magic spell | P first looks at the LEDs and then glances out through the windows for a second | |
| 23:27 | Sludge Thrower | P changes tool to Sludge Thrower, F points towards the left side-window | P looks at the screen, F looks out thought the windows and searches actively for the opponent. | F: wait! here ... |
| 23:31 | | P holds up the Clutcher aims towards the left side-window | P first looks at the LEDs and then out through the windows for the opponent | |
| 23:34 | sludge + miss | P throws sludge | P looks at the LEDs and then out again | |
| 23:36 | | F points towards a blue car parked in the opposite lane | | F: there was Troll-pelle! |
| 23:37 | sludge | P throws sludge in direction F is pointing | P and F look in the direction toward the opponent. | |
| 23:39 | Sludge-hit | | P and F look down at the screen. | P: yes!<br>R: did you get him?<br>P: yes I got him! |

During the game-event the player changes tool to the Sludge Thrower (23:27) He holds up the Clutcher towards the windscreen. He looks at the LEDs and then out in the direction designated (23:31). After another quick glance at the LEDs he throws sludge in the indicated direction (23:34). He looks out in that direction as the device plays a sound indicating that it is flying through the air. Thus, identification and manipulation are smoothly performed in sequence two times. Furthermore, the player holds the Clutcher in his line of sight. The player shifts visual focus between it and the traffic. This could be considered blended attention where traffic is in visual focus.

The excerpt in table 1 also displays a collaborative approach to blended attention. The partner is actively searching for the opponent (23:27). He identifies a suspected car and points it out to the player (23:36). The player then throws sludge in that direction (23:39). Thus, the partner makes the identification for the player.

There was also a type of Sludge Thrower use in which visual attention was solely on screen, like that previously discussed. We will, in the following, discuss such a case, even though detailed transcriptions have been excluded for brevity. In this case,

both the player and the partner look down at the screen on the PDA when the sound indicating peer connection is heard.

The player holds the Clutcher in her lap. She soon changes her visual focus to the LEDs and throws sludge in the direction indicated by the green light. They meet the opponent driving in the opposite direction and the locator LEDs switch in response and indicate that the adversary is now located behind them. They observe the locator LEDs and turn the Clutcher backwards so that the green LED lights up. Once more she makes a gesture to throw sludge with her eyes steady on the Clutcher. Neither the player, nor the partner, even once look out through the windows during this game-event, but identify the direction to the opponent player simply by looking at the locator LEDs. Still, as in the previous case, their interaction follows a sequence of identification and then manipulation.

To sum up, the Sludge Thrower was both used in a way where the players blended their attention and in way with *device centric attention*. This was similar to the way the Magic Wand was used. However, the Sludge Thrower provided a more interesting gaming experience than the Magic Wand, since the gameplay was often successful and conducted sequentially between identification and manipulation in the way that was intended in the design of this tool. The Sludge Thrower also provided a better experience according to the interviews. Several of the players thought that the Sludge Thrower was the most fun tool to use, even though it was considered somewhat difficult. A player said: "I think the Sludge Thrower is easiest to shoot with…but it is harder to hit with it". Another player preferred the gesture per se.

We suggest that the difference in success and experience between the Sludge Thrower and the Magic Wand can be understood with reference to the classical semiotic notion of indexical and symbolic signs. The gesture in the Sludge Thrower, i.e. the required movement of the Clutcher forward and downward, can be interpreted as an indexical sign [28], in the sense that it gets its meaning from the local context. Throwing implies that something in the context gets something thrown at it. In this case, the availability of an adversary in the direction of the gesture supports an interpretation of the gesture as a throw. The spell, on the other hand, is a symbolic sign, which means that it gets its meaning from a social convention. In brief interaction, such as in a traffic encounter, the indexical throw gesture is more intuitive and easier to understand than the more abstract gesture of a circle referring to a spell. When time is brief, and players are excited, it is possible that this minimal difference is of importance.

**Triggering electric shocks.** The Electro Squeezer requires no visual attention on the traffic for successful scoring. The player only has to pay attention to the sound indicating that an opponent is within wireless range. Then he can directly start to score points by pressing the Clutcher. Consequently, all the children quickly understood the concept.

Again, we identified two types of focus of attention during gameplay. We will start by discussing the type of gaming where the players blend their focus of attention. For brevity, we do not provide the transcriptions.

Just before the event the player and partner discuss what tool to use. The connect sound is heard. They look at the screen and the player selects the Electro Squeezer. The partner says "Push! Squeeze! You don't have to aim." He looks out of the windows in search of an opponent, while holding up the Clutcher in the line of sight. The

player squeezes the Clutcher while looking out. He suddenly says “there!” and then glances down on the PDA screen. He lifts his gaze and smiles, as he continues to squeeze the tool. Both the player and the partner catch a car, in the opposite lane, with their eyes. The player keeps on squeezing while holding up the Clutcher, aiming it towards the passing car. The partner waves towards the car (see figure 6). In this event, the player engages in what we have referred to as blended attention even though it is not required to score, i.e. he looks out through the windows while simultaneously interacting with the computer.

**Figure 6.** Blended attention

**Figure 7.** Device centric attention

We also observed a type of gaming where the players’ attention was centred on the devices. In the following event, the player and partner immediately look down at the screen as the connect sound is heard (see figure 7). The player holds the Clutcher in her lap and they both look at the LEDs, while she persistently squeezes the tool. After a while the player exclaims “aaa! there is only one left.” The player observes the power LEDs, which present the scores in the current exchange, taking no notice of the surrounding traffic.

Thus, the players used the Electro Squeezer in the same two ways as when interacting with the previous tools. The difference is that in this case, the visual focus on traffic, as displayed by the boys above, was not required to score points. We suggest that it occurred since the players found the visual presence of the contestants interesting and fun. In the interviews, the boys discuss the experience of meeting someone physically in a multiplayer game. The best part of the game, according to them, was:

> Bill: …the feeling…
> Erik: when you met someone…
> Bill: …you become sort of … it gets exciting somehow

Some children preferred this tool because they didn’t have to aim. The interviews reveal that they considered this to be especially good when something blocked their view of the opponent. Still, for other children this tool was not considered as fun as the Sludge Thrower, because it was only about squeezing.

### 5.2 Additional game interaction

The interaction discussed in the previous section covers events where players are engaged in multiplayer gaming. However, there are other parts of the Road Rager game, where the player does not interact with contestants. First, multiplayer gaming is preceded by a momentary boundary phase (peer discovery) occurring when two cars come within wireless range and the devices discover each other. Second, it is directly

followed by a short phase where network contact is dropped (peer loss). Finally, Road Rager is in single player mode during a longer phase where the devices are out of wireless range and the player is waiting for the next game-event. In the following we will discuss how the players focussed their attention in these situations.

**Peer discovery.** The peer discovery phase, presented through a distinctive sound, is brief and marks the transition from single-player mode to multi-player mode. The sound was supposed to give the player a quick "non-visual" notification to facilitate the immediate possibility of searching for the opponent. All the children understood the significance of this sound. However, instead of looking out the windows or at the locator LEDs in order to locate the opponent, the children most often watched the screen immediately after the connection-sound was heard. This includes both the player and the partners in the car. There are two feedbacks available on the screen that could have been of interest for the players at this moment. First, the screen provides additional visual confirmation that an opponent is in the vicinity, i.e. that the devices are connected, namely a big red square with the text "[*name of the adversary character*] is in your vicinity". Second, it provides graphic information about the opponent's character, consisting of a picture, a name text and the items in his possession, i.e. stars and frogs.

**Peer loss.** Disconnection of the wireless network was also signalled with a distinctive sound. The result of the game-event was then presented on the screen. This information attracted their attention. All the children immediately looked down at the screen in order to view the result of the game-event. Here the gameplay unfolded in accordance with the design intention.

**Out of wireless range.** The game prototype provided no manipulative challenges when network connection was lost. Still, the children engaged in various related activities. First, they tried out and practiced the different tools available. They experimented with the gestures and listened to the sounds they generated. Second, they looked for contestants. The children maintained a visual focus out through the windows of the car, searching for opponents, during most of the time between the game-events. Interestingly, this search for opponents was also eagerly pursued by the players who mainly displayed device-centric attention during the game-events. This identification work was done by looking for cars with children inside or for colours they thought the opponents' cars had. Looking for cars with specific colours was an activity appreciated by the children and was animatedly discussed. It was also something that was mentioned as a possible improvement during the interviews. A map was suggested where they would be able to see where the other car was and its colour. Third, some players used the Clutcher to "scan" their surrounding by holding it up and sweeping it back and forth, treating it as a kind of "directional radar" able to sense the proximity of opponents. Additionally, if the player occasionally forgot to perform this activity some partners commented on it as being necessary in order to discover the opponents. This was something that the children themselves had come up with, and it indicates that they conceived of there being a fictitious connection between the game and the surrounding physical world. Finally, they settled on the tool to use in the next encounter.

## 6 Discussion

Our user study provides initial feedback on how to design for interaction when the boundaries in a mixed reality world are very short-lived and when people move quickly around. The study is a starting point for understanding the possibilities of designing for this context as well as the requirements for doing so.

The interviews and the observations of the players during gameplay made it clear that these temporary encounters created a thrilling gaming experience, even for the partners in the cars. Several children mentioned that the feeling when someone was in the vicinity, and the search for the opponent, was fun and thrilling.

We have gained insights into how the users balanced their focus of attention between the traffic and the gaming device. We identified a type of gaming, which was observable in the use of all the three tools, where the visual focus of attention was directed solely towards the screen or the tangible interface, and never out towards traffic. This was a successful form of interaction, in terms of scoring, for the Sludge Thrower and the Electro Squeezer, but a failure when using the Magic Wand. Thus, for those tools, where identification was not necessary, the players occasionally did not engage with the traffic, and even when it was required they still did not do so. In that sense, it was also a failure for the design intention to require players to identify the opponent and thus engage in looking at the traffic in those situations. On the other hand, both the Sludge Thrower and the Electro Squeezer were also used in a way where the players blended their visual focus of attention on traffic with engagement with the computer.

The Magic Wand provided for a sequential unfolding of the tasks of identification and manipulation, which was not applied by the players. Instead they went straight into manipulation as soon as the connection sound was heard. Perhaps the pressing situation in those brief encounters pushed the player to go directly to action. We cannot conclude that demands for sequential unfolding of tasks should be completely ruled out in future designs. In game design, the easiest solution is not always the best. However, it is clear that this type of sequence of tasks, which requires a delay for more exact positioning, should not be a general design principle. Further, the Magic Wand, which was designed to require identification, and thus visual focus on traffic, generated the least amount of attention out of the windows. Possibly, this tool is too complex and demanding for the limited time available for gameplay in such brief encounters.

The Sludge Thrower provides a both fun and imaginative experience, and we observed frequent occurrences of blended attention. Here, the sequential unfolding of tasks was smoother. Even though it is only slightly different than the Magic Wand, the difference seems to be crucial. First, the Sludge Thrower requires weaker positioning and gives the players many chances to score. Second, the Sludge Thrower recognised an indexical gesture while the Magic Wand recognised a symbolic gesture with a more abstract meaning. Thus, the Sludge Thrower provided a tighter blend in the manipulation, but was more forgiving in terms of identification.

When using the Electro Squeezer the focus of attention was very much on the surrounding traffic, although it wasn't required to score points. Still the players enjoyed it. We suggest that the experience of being able to see the contestant makes a very simple gameplay more exciting. Thus, the success of the Electro Squeezer supports

the general design concept of drawing on meetings to make a game which is both comprehensive and challenging in an interesting way.

In general, it is difficult to enable gameplay when the lifetime of the game-event was so short. There is just too little time to engage in extensive identification before getting into manipulation. There is, of course, a possibility of developing other means to enable strong identification in future research. See-through displays are one alternative, or the use of interfaces on the device in the other car. The remote device could in some way announce that a player was sitting in a particular car.

However, our study also showed that the weak approach to identification was appealing to the children. On several occasions, the players successfully blended their visual orientation on traffic, with a focus on the computer interface. And they enjoyed identifying who they were playing against, even though it wasn't necessary for scoring. Weak identification, in this sense, adds to the exploration of the game landscape.

Furthermore, indexical gestures, such as throwing, make interaction more intuitive. Other examples for future design could be scooping, patting or hugging. These gestures are less complex than esoteric symbolic gestures of various kinds.

Finally, the users on many occasions looked at the screen for additional information than the audio feedback e.g. directly following peer discovery. Although, we thought of the graphical information as rudimentary, and not interesting in itself, it got lots of attention. In future research, it would be interesting to study whether a user interface with even less graphical information would engender more blended interaction.

To sum up, minimalism is critical for success when designing for brief lifetime in mixed reality applications. The features and tasks of the game have to be cut down to the minimum. Even such a meagre task as supported by the Magic Wand was too complicated. Of course, games should not be designed to be easy, but to provide interesting challenges. However, in this case, the challenges of the use context themselves are so difficult that the designer as a first priority should focus on making the concepts achievable. Then, social situations such as traffic encounters, could become new use contexts for mobile multiplayer games.

## 7 Conclusions

We have in this paper been concerned with how to combine and balance a player's focus of attention between traffic and a computer, while at the same time providing a game which is comprehensive, interesting and challenging. It seems possible to exploit contingent traffic encounters to create a both compelling and fun game experience. We observed two types of gaming concerning focus of attention. First, a type where the players focused their visual attention solely on the gaming device. Second, a type where they blended their focus on the mobile devices with a visual focus of attention on the traffic.

The study also suggests that neither support nor rewards were needed for the players to maintain a visual focus of attention on the traffic. Instead a blended experience occurs very much because the players accept and like the imaginative activity that playing in the same space allows. Exploration of the physical game space was a highly popular activity, and the experience of seeing the contestant made a very sim-

ple gameplay exciting. Often the players enjoyed identifying who they were playing against, even though it wasn't necessary for scoring. Consequently, weak identification in the design added to the exploration of the game landscape.

The approach taken in this project is to establish a mixed reality by the use of tangible user interfaces rather than see-through displays. See-through displays strongly influence the user to see the world as a mixed reality, whereas the approach in Road Rager rather depends on the user actively engaging in the creation of such an experience. Therefore it is not so surprising that we find both a type of focus where people mix their attention between traffic and the computer's interfaces, as well as a form of attention where the users did not engage in creating this experience. Still, it is possible to argue, based on this study, that TUIs could be an alternative if used in contexts and for applications where players find it interesting enough to actively contribute in mixing realities. As discussed, the children often interacted with Road Rager in ways in which the traffic, with people and cars, and the mobile technology with its user faces, came to create a coherent reality.

In conclusion, this study suggests that the possibility of enabling interaction within such a temporally restricted mobile situation, and the positive experience shown by the users, motivates further research into support for interaction in brief encounters. We have specifically addressed short encounters where people sit in the back seats of cars. But it is possible to imagine other brief encounters where people quickly move in and out of range, e.g. public transportation, elevators, and ski lifts. Encounters in such circumstances could provide a specific experience if the design of the services accounts for this rather particular use context.

## Acknowledgements

We would like to acknowledge the Swedish Foundation for Strategic Research, which funded this research through the Mobile Life research programme. We would also like to thank Mattias Östergren for the development of the MongerLib library. We would also like to thank Mattias Esbjörnsson, Daniel Normark and Alberto Frigo for helping us out at the field trial, and Barry Brown as well as anonymous reviewers for valuable comments. Finally we would like to thank Matthew Chalmers for shepherding this paper to its final state.

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