Zombies on the Road: A Holistic Design Approach to Balancing Gamification and Safe Driving

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ABSTRACT

This paper explores novel driving experiences that make use of gamification and augmented reality in the car. We discuss our design considerations, which are grounded in road safety psychology and video game design theory. We aim to address the tension between safe driving practices and player engagement. Specifically, we propose a holistic, iterative approach inspired by game design cognition and share our insights generated through the application of this process. We present preliminary game concepts that blend digital components with physical elements from the driving environment. We further highlight how this design process helped us to iteratively evolve these concepts towards being safer while maintaining fun. These insights and game design cognition itself will be useful to the AutomotiveUI community investigating similar novel driving experiences.

Author Keywords

Road safety; driving games; gamification; augmented reality; design approach; serious games.

ACM Classification Keywords

H.4.3 Information Systems Applications: Communications Applications; H.5.2 Information Interfaces and Presentation (e.g., HCI): User Interfaces.

INTRODUCTION

The largest demographic segment involved in car crashes are young males. Young males typically score high in sensation seeking behaviours [28]. Perhaps lesser known are the following facts: a) young males are also more prone to being bored, which is a hard-wired personality factor that cannot be changed [14]; and b) sensation seeking and boredom proneness are directly correlated [28]. A lack of stimulation while driving can lead particularly young males to feeling bored, and this feeling may then trigger the seeking of sensations (e.g. speeding) or distractions (e.g. mobile phone use) [10], which in turn can lead to accidents. In our previous work, we therefore made the argument that intervening in the driving task in such a way that it makes safe driving more fun, engaging and less boring can have road safety benefits [24].

Our work does not claim that boredom is the only factor, nor are we yet able to quantify its contribution to young males' choice to speed (other reasons may include, e.g., to impress their peers) or use of their mobile phone (other reasons may include, e.g., to satisfy their urge for social connectedness) while driving. Nevertheless, there is a plausible correlation that warrants further investigation, particularly in light of existing strategies that fail to address the increased road safety threat of mobile phone use in the car. Our research therefore focuses on boredom, which remains a relatively unexplored area for driving safety research.

While we have previously argued for, and justified, a gamification and AR approach more broadly [24], in this paper we argue more specifically for video game design thinking and describe how it helps to strike a balance between the conflicting aims of safety and fun. Further, we share our insights from using our process and provide concrete (albeit brief) design examples, good and bad, which illustrate the unique challenges and considerations that arise when designing gameful real-time interventions in the safety critical driving context. It should be noted that the contribution of this paper lies in proposing, describing and evaluating game design cognition in the driving context, rather than the design examples themselves, for which we were only able to present a selected few within the scope of this paper.

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Overall, our aims are to design and develop interventions that: *re-engage drivers in the driving task* (Aim A), in particular young males during mundane driving situations so that they do not become bored (potentially preventing risk taking *passively*); and that *encourage safer driving practices* (Aim B) more *actively* by making them more fun and rewarding. While this paper focuses on the design process of such interventions, we anticipate to investigate in what way different interventions and stimuli mitigate risks or increase driver performance in the future.

RELATED WORK

Enhanced Experiences in the Real World

In recent years, we have begun to see novel concepts aimed at enhancing experiences in the real world facilitated by technology. For our work, we focus on the concept of gamification, which is best defined as the use of game design elements in non-game contexts [6]. Gamification has been used in various fields to motivate people by facilitating engagement and fun [24]. Fitness apps have appeared, like Zombies, Run! (zombiesrungame.com) or The Walk (thewalkgame.com) that use game elements to encourage people to undertake more exercise. These examples immerse players in an interesting narrative, engage them in missions and provide rewards. It is well established that young males respond to digital games [3], and we aim to leverage this pre-existing interest by applying gamification as a means of encouraging safer driving behaviour.

At the same time, new technologies such as Microsoft HoloLens (microsoft.com/microsoft-hololens) and Magic Leap (magicleap.com) enable advanced augmented reality (AR) experiences that further amplify the immersion. We are exploring the translation of these AR concepts into the driving context, which will be enabled by in-car 3D volumetric head-up displays (HUD) or wind screen displays [e.g. 2]. However, applying gamification and AR concepts to the car is highly challenging due to conflicting game and road safety objectives [7], as well as concerns related to distraction and cognitive load [12]. Therefore, it requires careful considerations and design approaches, which we discuss in this paper.

Novel Driving Experiences

Advancements in cooperative intelligent transport systems (ITS), advanced driver assistance systems (ADAS) and semi-autonomous driving functionalities, novel in-vehicle information systems (IVIS) and human-machine interfaces (HMI), as well as electric cars have opened up a new design space for creating novel or enhanced driving experiences. While the focus of AutomotiveUI is typically on the evaluation of novel IVIS and HMIs, these novel experiences were increasingly discussed, such as Social Car concepts [22,25], Electric Vehicle Information Systems [21], and User Experience of Autonomous Driving [20]. Others, such as Loehmann et al., studied experience design in the context of electric vehicles and developed Periscope [18] and Heartbeat [17], which allow passengers to explore the outside environment and experience energy level and flow in electric vehicles. We explore concepts that aim at making mundane driving situations more exciting and engaging.

Gamifying the Driving Experience

The use of game elements has previously been explored as a means to influence driver behaviours. Adding an intervention to the road infrastructure, the Speed Camera Lottery (thefuntheory.com) encouraged drivers to slow down. Drivers who did not speed were entered into a lottery where they could receive cash prizes funded by drivers fined for speeding. A number of approaches are smartphone-based but do not offer interaction during the drive. For example, the app VW Smile Drive (smiledrive.vw.com) records trips and allows users to compare them with friends. Fitz-Walter et al. looked at motivating learner drivers to undertake more diverse practices by adding a road trip game to a learner logbook [8]. The app Driving Miss Daisy [26] on the other hand does provide real-time interaction while driving. It performs a gamified driving style assessment, where the performance is evaluated by a virtual passenger on the back seat, who cheers or whimpers depending on the driving performance. Extending such work by adding elements apart from the smartphone, Rodríguez et al. [23] propose to gamify driving activity by providing awareness through ambient devices in order to prevent distractions. Specifically, they presented users with daily driving challenges and utilise haptic feedback (vibration) as well as a rearview mirror display to provide feedback in an unobtrusive way. Other researchers used existing HMIs and integrated game elements into a dashboard display to encourage fuel efficient driving [5]. Few of them discuss their design process in detail, especially with regards to ensuring safety.

In conclusion, we increasingly encounter enhanced experiences in the real world facilitated by AR and gamification. At the same time, game elements are increasingly used in the driving context. However, few approaches leverage the opportunity to intervene during the drive to contribute to better driving behaviours. In this paper, we present our design process that helped us striking a balance between safe driving and fun, and that we hope to be useful to the AutomotiveUI community investigating novel driving experiences.

GAME DESIGN COGNITION

In this paper, we argue for a holistic, iterative game design thinking as a useful method in the design of driving experiences. It is inspired by game design cognition proposed by Lopes and Kuhnen [19]. Based on their industry experience, they describe how a practical video game design process involves a mixed approach between top-down and bottom-up cognition. It consists of five layers, which break down the cognitive process behind game design into: 1) *verbs*; 2) *mechanics*; 3) *core* (features and content); 4) *theme*[1]; and 5) *concept* (see Figure 1).

In turn, we will describe the individual layers of game design cognition. We will discuss their role in the design of driving related experiences in general terms before providing concrete game design examples in the next section further illustrating the benefits we see of this process to the AutomotiveUI community.

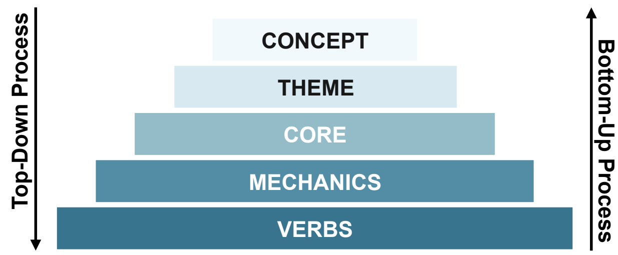

Figure 1. Breakdown of the game design cognition process into five layers (based on Lopes and Kuhnen [19]).

Verbs. *Verbs* are simple actions that allow users to work towards a goal, such as jumping, running, braking, shooting, or making a decision. Available *verbs* depend on the current game state, e.g. whether the player's character is on foot or in a car. They are triggered by physical activities, usually pressing buttons on a controller, keyboard, or mouse. Consequently, a set of simple physical activities facilitates step by step gameplay.

Transferring this to the design of safe driving experiences, we need to identify the available input modalities during the driving task. These include (and are not limited to) accelerator pedal, brake pedal, steering wheel, clutch and gear stick, the driver's eyes, and various buttons. They are used to accelerate, brake, steer, select gears or reverse drive, scanning the environment, and activating lights, etc. The number and type of available input modalities in a car will impact the remainder of the design process and ultimately determine which action and, more broadly, which experiences can be made available to the driver.

Mechanics. The *mechanics* of a game experience are the brain, the gears spinning under the hood to realise a game's rule set. The *mechanics* are particular components of a game, at the level of data representation and algorithms [15]. They process and validate user input based on available verbs. Subsequently, they output the result of an action, which hopefully is what the player had intended to do. To provide an example, a player might have pressed a button to shoot a target. The mechanics will take intensity, aim and nearby obstacles into account to figure out if the target was hit. Therefore, in this layer, designers explore and refine rules that are triggered by the previously identified verbs.

In the design of gameful driving experiences, the *mechanics* will have to incorporate traffic rules and characteristics of safe driving behaviours. These need to be determined against the real-time real-world driving environment and context. For example, it needs to be analysed, e.g., if the driver is acting according to current traffic rules, if the current speed is within limits, if the vehicle is within bounds in terms of road lanes, or if the driver is keeping a safe distance to the vehicle in front. Apart from traffic rules, an augmented driving experience may furthermore add playful elements such as virtual items that can be collected, but this would need to be carefully considered. Therefore, to put it more broadly, the rule set for driving experience does not merely include traffic rules and safe driving practices, but may actually include anything except risky or unsafe driving behaviours.

In the future, cooperative ITS and (semi-) autonomous cars will be able to serve as a basis that allows for even richer game mechanics. Basically, the more we know about the real-world based on sensing and state detection, the more mechanics are available. Those *mechanics* could be aimed at, e.g., increasing drivers' driving skills and vehicle mastery despite increased autonomy, or allowing for smoother road sharing between automated and human-operated cars. Furthermore, we will be able to create augmented experiences that make use of output devices such as volumetric 3D HUDs [2] that place content at the right position in the real-world and where it makes sense from a safety perspective.

Core. The third layer, the *core*, consists of abstract contents and features: Contents are the things a player can see and touch (e.g. an object to hit a target object, the target object itself, etc.); features are behaviours and characteristics (e.g. the fact that one can use the object to hit the target object). Essentially, the *core* describes what type of challenges (e.g. hit the target) the player will experience. Accordingly, this layer allows the designers to give thought to the skeleton of gameplay pieces such as tasks and obstacles.

Some elements of the core come predefined by the driving context. These include the current driving situation such as following the speed limit behind other cars or rush hour stop-and-go traffic. By themselves, they are often deemed boring and lack stimulus for the driver. It is therefore exactly those scenarios we intend to enhance by adding engaging elements to them.

According to Lazzaro, "games provide players with the opportunity for challenge and mastery" [11]. However, any challenge needs to be provided for the player's skill level, i.e., those who first start using the game to those who become good at it to those who master it. That way, the user will feel competent and therefore motivated from early on. For instance, a challenge might only consider the current

[1] Lopes and Kuhnen [19] use the term *context*. We opted for *theme* to avoid confusion with *concept* and *content*.

speed in the beginning, later the steering as well, and at some point how well the driver is using the clutch.

Although not immediately apparent, it may be helpful to borrow the concept of flow [4] from positive psychology. Flow refers to a state of absorption and engagement where one's abilities are well-matched to the demands of the task/challenge. It offers a feeling of being perfectly challenged (neither under or over stimulated), happy, motivated and cognitively efficient. When in a flow state, one becomes totally absorbed in an activity and irrelevant thoughts and perceptions do not enter consciousness. Flow has been investigated for video game design [16,27], sports science, education, etc., but it has never been applied to the driving task. Having said that, coming from a road safety angle, the conceptually similar task-capability interface theory by Fuller [10] does describe the dynamic interaction between task demand and a driver's capability as determinants of driver behaviours such as speed choices and gap acceptance. Therefore, considering flow in the design of enhanced driving experiences (i.e., how to provide (safe) driving challenges that match a driver's skill) can potentially help reduce risk taking behaviour and help drivers to actually enjoy driving safely, which aids user acceptance.

Theme. As part of the fourth layer, the *theme* adds context to the core layer. It defines the narrative and its look. It answers questions such as "which characters or entities are involved, and in which circumstances?" To provide an example, the core might contain a challenge to save someone or something. The *theme* will further specify if the players have to look for e.g. a princess or save the world from an alien invasion. Therefore, various themes can be come up with for the same core challenge that can be adapted according to specific target audiences (e.g. young male western). The theme has a strong impact on the user's first impression and its general perception of the game itself. However, the *core* needs to be able to stand for itself. A weak *core* can hardly be made up for by a good *theme*.

Nevertheless, the *theme* helps immerse players more deeply into the game. In the driving context, it potentially provides users an incentive to act safely throughout their driving journey. Similar to the other layers, the choice of *theme* will not be independent of the driving context. Themes and metaphors for specific driving situations (e.g. keeping a safe distance to other cars while cruising) need to be scrutinized carefully, in order to encourage the driver to achieve the best driving performance. We will elaborate on the use of different themes in the next section.

Concept. A *concept* is the abstract description of a game. It typically contains an overview of the game's style, setting, and plot and serves as the ultimate definition of the game by tying all the other layers together. As such, it provides a vision and focus, e.g. when various contents or features are refined or revisited.

In the design of driving experiences, the *concept* can be used to summarise and communicate a novel design. It can represent the result of a bottom-up cycle that started off by identifying available input modalities and considering implications given by the driving context. It can also be a starting point of an iteration that initially emphasises on player experience and fun. As such, it can be an integral part of an iterative process where all layers are repeatedly revisited.

Related approaches. Similarities can be drawn between the chosen game design cognition and the framework proposed to build calibration games [9], where core tasks for different calibration types are listed and game mechanics related to them are identified. This is similar to a bottom-up design approach, but focuses on calibration tasks only. The Mechanics, Dynamics, and Aesthetics (MDA) framework [15] is another useful tool for understanding games in that it breaks games into three distinct components that are rules, systems, and fun and establishes their design counterparts as mechanics, dynamics and aesthetics. This can be a useful tool to help guide design choices, but using top-down and bottom-up cognition provides a more detailed approach, especially when developing a game with a serious purpose. Similarities can be drawn between verbs and procedures, one of the formal elements that form the structure of a game proposed by Fullerton [11]. Procedures describe methods of play and actions that players have at their disposal to achieve the games objectives, for example in the game Super Mario Bros. (mario.nintendo.com) pressing the A button will allow Mario to jump, or swim when he is in water.

EXAMPLES & LESSONS LEARNT

In this section, we discuss the usefulness of bottom-up / top-down design cognition and the awareness of its layers through concrete design illustrations and by showing how the designs evolved using this process. It provides further insights to this process from our experiences in working at the intersection of road safety psychology and video game design theory. The illustrated driving games address the two aims mentioned earlier: A) fun: re-engagement in the driving task (i.e. making mundane driving more fun, potentially leading to passive safety benefits); and B) safety: active encouragement of safer driving practices. During the design process, we ran into several roadblocks and learnt valuable lessons. In turn, we discuss how the layers of the bottom-up / top-down design cognition provided insights that helped us to better strike a balance between safety and fun.

EXAMPLE PROCESS I: From Bowling to Angry Birds

We initially approached aim A top-down and focused on the design of engaging interventions for mundane driving scenarios. Inspired by existing video games, we arrived at a game scenario that uses the car as a means to trigger the release of a bowling ball towards pins. A sketch of this early stage concept is depicted in Figure 2 (top). This could be applied to any mundane driving scenario that requires the car to stop, e.g. approaching a traffic light, and make this driving task more engaging. The ball would be released closer to an optimum bowling path the smoother the breaking and steering action during the stopping. This could essentially turn every stopping at a traffic light into a fun mini bowling game. However, this game presents a road safety implication: In bowling, the best strategy is to release the ball in a powerful and fast fashion. Therefore, applying this theme could encourage drivers to approach the traffic light at a higher speed and to brake hard.

Using bottom-up cognition, we can dissect the game into verbs (braking and steering), mechanics (smooth braking and accurate steering, stopping at the correct position), core (associate the mechanics with an object hitting a target), and finally replace the problematic bowling theme with a more appropriate theme: a blend of darts and Angry Birds (angrybirds.com). Using this theme, the target in our game concept is a bull's eye (bottom, Figure 2). The bird (the dart) positioned on the bull's eye could visualise the driver's performance regarding smoothness of braking (y-axis) and steering (x-axis).

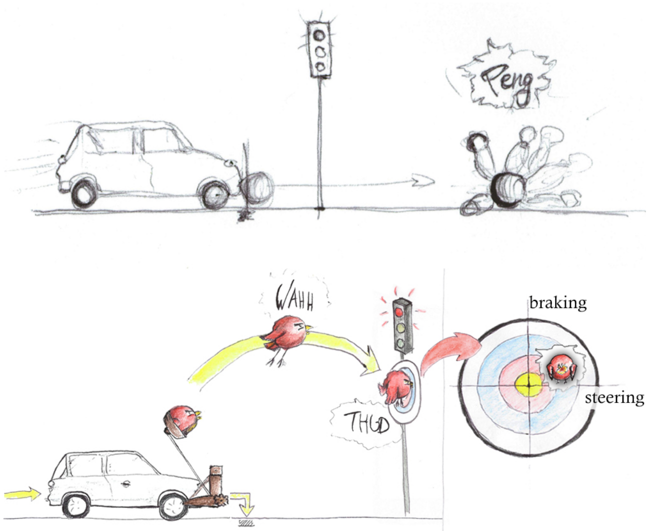

Figure 2. Top: Sketch of an early stage concept using a bowling theme. Bottom: More appropriate theme combining darts and Angry Birds.

This example illustrates the importance of carefully choosing themes. While many themes during this process may appear fun, only few will overlap with safe driving practices. Furthermore, it also highlights the need for multidisciplinary teams approaching the game bottom-up (road safety experts) and top-down (video game design experts) in order to strike a good balance between safety and fun. Breaking the game down into the described layers not only aids communication between team members but also helps identifying and addressing design implications.

EXAMPLE PROCESS II: Zombies on the Road

In this example, we initially approached Aim A and B more bottom-up. We focused on the mundane driving activity of cruising at a continuous speed, e.g. on major urban roads or freeways, and encouraging safer driving practices by discouraging tailgating. Tailgating is the practice of driving too close to a frontward vehicle, at a distance which does not guarantee that stopping will avoid collision. Vehicles are usually required to drive at least three seconds behind the vehicle in front of them (longer under poor visibility or road conditions). This rule would guide the game *mechanics* (the *verb* here being speed selection, which is determined through the use of the accelerator pedal and brake pedal).

At the *core*, the idea is that there is a radius around each car, which may not be entered by other nearby cars (Figure 3, top). Crossing the minimum allowed distance to a frontward vehicle results in not being able to complete the challenge.

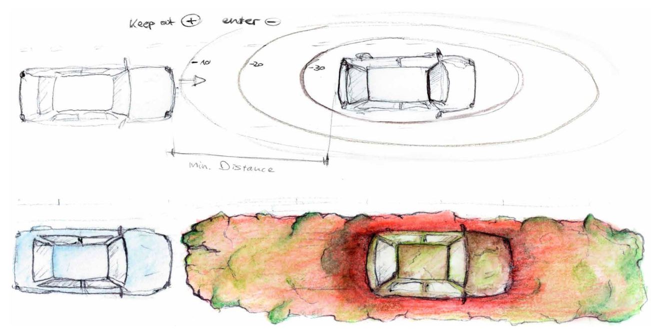

Figure 3. Challenge to encourage drivers to keep the recommended distance of 3 seconds and avoid tailgating. The first image represents the core idea and the second image is adapted to a Zombie theme.

We then added a zombie narrative as part of the *theme*, which could later form part of an overarching zombie *concept* (a popular concept in game design). In this *theme* example, the aim is to avoid close encounters with frontward infected zombie cars. It overlaps with the desired objective of keeping a safe distance to frontward vehicles. Figure 3 (bottom) shows a higher fidelity version illustrating this *theme*, which in this instance surrounds zombie cars by an 'infection cloud', which could be conveyed through a 3D HUD [2]. This cloud is more infectious the closer one follows, increasing the player's infection level, which then disadvantages their extended game play (further discussed under **Solution 3** below).

Problem 1: Exploration (pushing game boundaries). From a top-down and user-centred perspective, the above theme appears to represent a typical, fun game scenario for young males. Indeed, video games typically allow for multiple strategies to achieve a goal [11] and invite exploration of the unknown and pushing the game's boundaries. As part of this, games usually provide immediate negative feedback to users. However, this does raise issues in the road safety context (bottom-up perspective) because the game's negative feedback can be perceived as intriguing and fun. It might be a tempting to explore self-destruction rather than avoid a zombie infection. In the driving context, we cannot follow these standard top-down strategies that could motivate undesired behaviour (so driving close to an infected zombie car, which equates to tailgating). How would we prevent this behaviour, which is unsafe tailgating?

Solution 1.1: Adjust user feedback. One solution is to sacrifice this fun aspect and discourage exploration. This could be achieved by either only providing low-fidelity user feedback that essentially equates to 'invalid input' (e.g., audio beep) or no feedback at all (the better alternative would need to be tested). That way, exploring the game's boundaries will potentially be less tempting.

Solution 1.2: Replace the core and theme. Another solution would be to emphasise the bottom-up approach and revisit the *core* and *theme*. Any related theme that involves the *core* of staying away from something (e.g. a contaminated leak or guards) faces the same problem. Consequently, we changed the *core* towards extending our frontward facing area that is then impacted by others. This lead to a transport narrative that consists of driving something like a dynamic forklift (Figure 4). The challenge is to carry zombie-antibiotics without bumping into frontward vehicles. By avoiding tailgating, players ensure none of the valuable cans of antibiotics are punctured by protruding spikes of the frontward vehicle. The more punctures are in the can, the quicker the antibiotics are lost, which again disadvantages the extended gameplay (see Solution 3). This *core* and *theme* reduces the temptation of exploring the game's boundaries because it does not obviously lend itself to drive closer behind the car once the can has been punctured.

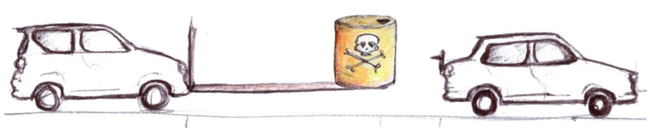

Figure 4. The transportation metaphor leaves less room to explore unsafe behaviour.

Problem 2: **Game is too focussed on a single task**. From a road safety perspective, it seems concerning that during the challenge players may be too focused on keeping the right distance. This one task might distract from other safe driving tasks such as checking mirrors or scanning for potential hazards.

Solution 2: Add gamified scanning. A solution to this problem is providing multi-task challenges. In this case, we can add a gamified version of scanning the driving environment, e.g. by counting objects. It is important to emphasise, though, that if the objective is not about the act of driving, then by definition, it is *distraction* [29]. For example, challenging a driver to press a steering wheel button for every nearby car of a certain colour may lead to an increased situational awareness as a result from scanning the driving environment and being attentive. However, counting objects that are not driving related, such as hidden weapons that have been added using AR, may cause distraction. Furthermore, while scanning the environment is driving related, pressing a steering wheel button is not. Nevertheless, the advantages of scanning may outweigh the disadvantages from pressing the button. For example, a very small amount of distraction is acceptable (similar to that associated with changing AC temperature) if it comes with an associated benefit to driving behaviour. At present the situation is that many young drivers are bored and are easily distracted in the car. The best solution may involve a very small degree of distraction balanced by an increase in safe driving. However, this aspect would need to be carefully tested in the evaluation of the game design in the future. However, in relation to the game design cognition and contrary to a purely top-down approach, emphasising the bottom-up approach will help identify these conflicting objectives early on.

Problem 3: Isolated mini games. Treating each challenge as an isolated mini game might not sufficiently motivate the player to complete the challenges as instructed. This might require a more immersive narrative that sets the scene for each individual game.

Solution 3: Gameplay outside the driving context. Any game offers room for extensions. The zombie example above focuses on one driving scenario. That is, keeping a safe distance to the car in front while cruising to avoid tailgating accidents. However, the concept could be spun further and engage users in other types of driving scenarios (e.g., reappropriating the Angry Birds example to Zombie Birds theme) as well as a narrative before and after the drive that ties it all together. As such, the drive itself might just be part of a bigger gameplay that extends beyond the drive. The drive is then used as an activity to gain rewards that benefit the player, e.g. power-ups or lives. As a result, players might be more prepared and motivated to complete the driving challenges.

DISCUSSION

In contrast to a purely top-down or purely bottom-up approach, being aware of all layers and approaching them from both ends in multiple iterations helps to identify pitfalls early in the design process. Without this awareness, designers might intuitively focus on one approach and miss out on the benefits of the other. In certain scenarios, such a focus might indeed make sense. For example, using a top-down approach, a game designer breaks a broader concept into smaller parts. This may be useful in the design of video games that revolve around existing themes. If existing stories from other media such as books or movies are transferred to a video game, a video game design company then creates the game based on this concept and subsequently moves into the remaining four layers as a next step. Addressing the other end of the spectrum, Adams [1] argues that a purely "bottom-up game design is an elementary mistake." He describes it as an error that is often made by people who fail to put the player and the enjoyment first. We argue that designing gameful experiences for the car constitutes unique prerequisites. It requires a balance between fun and safety, and therefore a balance of the bottom-up and top-down approach.

Flatla et al. [9] and Hall et al. [13] argue for a focus on the desired objectives in the design of serious games. In our case, this means the game has to operate within clearly defined safety constraints first and foremost. That is, the designer faces safety critical constraints provided by traffic rules and as the goal of safe driving. In moving from *driving* to *games*, the main objective of driving must be maintained. The game should not include any non-driving related objectives; it must be about the driving.

A second benefit of game design cognition is with respect to the nature of augmented reality applications. Video games for PCs, smartphones, or consoles commonly employ a completely virtual game environment. Accordingly, input and output modalities have been well established and creative freedom in the concept design of virtual game environments is assumed. As a result, there are few unknown constraints to be considered, which may cause designers to prefer a top-down approach. In a driving related game, however, a player will not be immersed into a virtual game environment but rather an augmented one. The real-world driving environment represents a novel gaming environment. This leads to the following challenge: the designer cannot discard real-world elements such as infrastructure and nearby vehicles. This results in a narrowing of creative freedom and poses further implications that are best addressed in a bottom-up fashion. Being aware of both approaches and applying them in an iterative way ensures that such key implications will be incorporated.

Related to the above argument, we essentially treat the car as a novel game controller. Rather than asking players to use multi-touch screens, console game controllers, or computer keyboards, any in-car game will have to make use of in-car user input devices. The *verbs* (the bottom layer) that form the basis for user input have already been well defined for established gaming platforms (e.g. smartphones, consoles, PC). The car, however, is a novel gaming platform. The basics are in their infancy, need to be established first, and carefully considered against the safety constraints. Game design cognition provides awareness of this design challenge. A bottom-up cycle can help design a game experience based on available input modalities and primitive user actions that make sense in the car. Once these modalities and actions are established, and our paper contributes towards this goal, it may be that a top-down approach for real-world driving games will be more favourable in the future.

To summarise, a structured, iterative game design approach consisting of bottom-up and top-down cycles helps focus on real-world objectives such as safe driving practices and supports dealing with the idea that the real-world driving environment represents a novel gaming environment and the car a novel game controller.

CONCLUSION AND FUTURE WORK

We adopted a comprehensive design process based on game design cognition [19] and showed how it can be applied to the design of driving games and novel driving experiences that strike a balance between road safety and fun. Focusing on the more common top-down approach (often recommended by video game designers [1]) can easily neglect crucial safety aspects. In order to prioritise safety over fun, we recommend emphasising a bottom-up approach. In order to strike a balance between safety and fun, we recommend rapid iterations between bottom-up and top-down, which in practice is not linear but organic. Lastly, we showed, through concrete examples and illustrations of design sketches and interaction concepts, how the layers of game design cognition can aid the thinking and design process, which we propose is useful to the AutomotiveUI community's goal of "enhancing the driver experience."

In the future, we will report in more detail our final game designs and their implementation and evaluation. As the expected outcome, this will deliver new insights for the design of safe driving related stimuli grounded in road safety psychology, video game design, and user participation. Lastly, it is expected that the evaluation will contribute significant new knowledge about the role boredom plays in risk-taking behaviour of young males.

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