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AR and Gamification Concepts to Reduce Driver Boredom and Risk Taking Behaviours

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ABSTRACT

Young males are over-represented in road crashes. Part of the problem is their proneness to boredom, a hardwired personality factor that can lead to risky driving. This paper presents a theoretical understanding of boredom in the driving context and demonstrates convincing arguments to investigate the role of boredom further. Specifically, this paper calls for the design of innovative technologies and applications that make safe driving more pleasurable and stimulating for young males, e.g., by applying gamification techniques. We propose two design concepts through the following questions: A. Can the simulation of risky driving reduce actual risky driving? B. Can the replacement of risky driving stimuli with alternative stimuli reduce risky driving? We argue that considering these questions in the future design of automotive user-interfaces and personal ubiquitous computing devices could effectively reduce risky driving behaviours among young males.

Author Keywords

automotive; boredom; gamification; road safety; sensation seeking; ubiquitous computing

ACM Classification Keywords

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

INTRODUCTION

Worldwide, over one million people are killed and an additional 50 million are seriously injured on roads annually [37]. The heaviest road toll (deaths caused

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annually by road accidents) is paid by young drivers [5]. Young male drivers are at a substantially higher risk of committing and repeating speeding offences [50] and being involved in speed-related fatal accidents [29]. Young male drivers are also more likely to be distracted while driving, especially through mobile phone use [6], an issue authorities struggle to address.

There are many underlying factors for the over-representation of young males in motor vehicle crashes. This paper presents arguments to focus on one of them, boredom, which has received limited attention to date [24]. One definition of boredom describes it as a 'state of relatively low arousal and dissatisfaction, which is attributed towards an inadequately stimulating environment' (p.3 [33]). In the driving context, boredom leads to the following problem, which is also illustrated in Figure 1 on the following page: If the driving environment is not providing enough stimulation, drivers tend to *seek sensations* by taking risks. This sensation seeking behaviour not only includes increasing speed or other risky driving manoeuvres, but also diverting attention away from the driving task [16], e.g. by using a mobile phone.

Young males often score highly on sensation seeking measures, and tend to be prone to boredom [2, 12, 26, 49, 53]. In fact, their proneness to boredom is a hardwired personality factor [24]. This suggests that it may be unchangeable and that existing road safety strategies (e.g. education programs, punitive fines) may be conceptually flawed in addressing this cause of risk taking behaviour in this population. Since young males are also over-represented in car crashes [5], they therefore represent an important target audience for innovative interventions to alleviate driver boredom.

This paper aims at

- presenting the theoretical grounding from the psychology and road safety literature that boredom may have an influence on risky behaviour, particular in young males;
- grounding Augmented Reality (AR) and gamification approaches to solve the problem and providing research questions associated with these approaches; and finally

c) inviting researchers to join our efforts around the proposed concepts and research questions in this problem field.

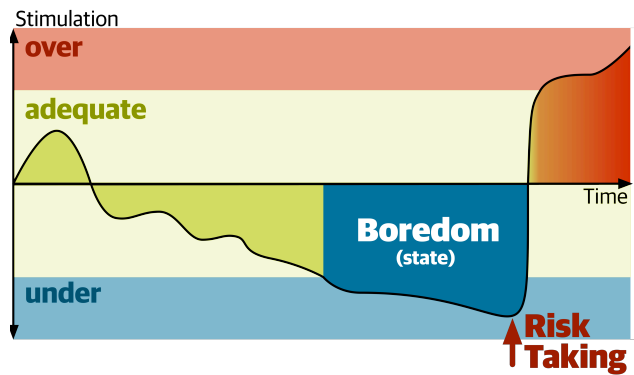


Figure 1: Boredom leading to risk taking in the driving context

LIMITATIONS OF EXISTING STRATEGIES

Existing strategies and road safety technology interventions have had only limited effects on reducing risky driving behaviours associated with boredom:

As mentioned above, the hard wiring of the low-boredom threshold in young males means that it may not be malleable through *training and education* programs [24]. This means that such programs may be ineffective in preventing boredom related crashes. They only address young drivers' lack of experience.

Punitive fines are difficult to enforce, in particular for distracted driving. Covert and overt cameras or random roadside testing are ineffective due to the surreptitious and passive nature of the behaviour. Punitive approaches can also exacerbate associated risks. For example, making mobile phone use illegal while driving has been shown to increase crash risk [27] as it may encourage drivers to use their mobile phones in a covert manner that is even more distracting.

Awareness campaigns are often directed at the general driving public as a whole. They are not customized to the personal circumstances of the driver nor are they tailored to them and to the specific driving situation in real-time.

Advances in *vehicle safety technologies*, e.g. collision avoidance systems such as autonomous breaking, only reduce the extent of drivers' risk. While this increases the safety net, these technologies do not target the core problem, the risky behaviours themselves. Paradoxically, these types of technologies have been shown to, in fact, *increase* risky behaviour through what is known as the *risk compensation effect* (*risk homeostasis* [51] or more recently *risk allostasis* [15]), whereby people tend to adjust their behaviour in response to the perceived level of risk.

The paucity of research on strategies that tackle driver boredom left authorities unable to deal with technologies

and devices, such as the mobile phone, that enter the safety critical car space. We argue that emerging technologies provide opportunities to design novel approaches that complement existing safety strategies and address their weaknesses, e.g. rewarding safe driving behaviour rather than punishing risky driving, or allowing interventions to occur in real-time and before risky driving behaviours occur.

FROM FOE TO FRIEND: USING SOCIAL COMPUTING DEVICES TO AID IN SAFER DRIVING BEHAVIOR

Authorities and the road safety community often perceive new social technologies that enter our cars first and foremost as a threat that aggravates risky driving behaviours by distracting drivers. Alarming, many road safety researchers tend to focus on their safety impacts only *after* they have become popular and a road safety threat, cf. smart phones and texting [6]. Regardless of punitive strategies, new technologies will continue to be used within the car, especially by young males - who in addition to being prone to boredom are also seen as early adopters of such technologies. New distracting ubiquitous computing devices fulfilling our insatiable need for social connectedness will enter the car space in the foreseeable future, which could pose an even greater challenge to road safety, e.g. new wearable computing devices (e.g. smart watches), Augmented Reality (AR) glasses (e.g. Google Project Glass) and Head Up Displays (HUDs, e.g. Pioneer CyberNavi).

To address this imminent road safety problem, a conceptual breakthrough is needed. Instead of indiscriminately and futilely rejecting and demonizing such technologies, we aim to encourage the discovery of new ways to capitalize their usage towards bringing about safer driving practices by addressing boredom in young, male drivers.

BOREDOM

There is no universally accepted theory or definition of boredom. As noted above, Mikulas and Vodanovich defined boredom as a 'state of relatively low arousal and dissatisfaction, which is attributed towards an inadequately stimulating environment' (p.3 [33]), whereas Eastwood et. al [13], e.g., defined it as "the aversive experience of wanting, but being unable, to engage in satisfying activity". Furthermore, boredom can be construed as an element of sensation seeking - as measured by the Sensation Seeking Scale [52].

The experience of boredom includes attentional deficits, negative affect, non-optimal physiological arousal, and difficulty concentrating. These cognitive and physiological correlates of boredom may negatively impact on a person's ability and motivation to perform various tasks. People prone to boredom are more likely to make errors on cognitive tasks [31], more impulsive [32], less attentive [18], and more aggressive and angry [7]. Each of these issues can considerably impair a person's ability to drive safely.

Boredom vs. monotony

It is important to distinguish boredom from monotony. The monotony of a task can be seen as an objective characteristic of the task. For example, in a driving experiment the number of corners driven per mile is an objective measure of monotony. However, different individuals will vary in their appraisal of the task as monotonous [17]. Participants may keep their attention focused on other elements of the driving experiment (e.g. the speed of their vehicle) that provide more variety and stimulation, and therefore not see the task as monotonous. Given differences in participants' view of the task as monotonous, their ratings of their boredom during the driving task will also differ. Other factors will also influence the person's rating of boredom, such as their physiological arousal, level of attention, and their perception of the difficulty and meaningfulness of the task [8, 14, 36]. A person may view driving as boring even if they do not see it as monotonous, and this may negatively impact their driving behaviour.

Boredom vs. fatigue

It is also important to differentiate boredom and fatigue, although the two concepts share many similarities. The causes of fatigue and boredom can be similar. Fatigue can occur after a person performs physical and/or mental activity without adequate rest [44], such as after/during an extended drive. Boredom may also occur in such a situation.

The consequences of fatigue can also be similar to boredom, including cognitive deficits and difficulty with attention [4, 30, 48]. However, there are also notable differences between fatigue and boredom. Most importantly, boredom can occur very soon after commencing a task, whereas fatigue occurs after a period of sustained activity [44]. Relatedly, a person who finds driving uninteresting may experience boredom whenever they drive safely, whereas they would likely experience no fatigue on most trips. Subjectively, people can differentiate between the feelings of boredom and fatigue, so their behavioural responses to alleviate these feelings are also likely to differ. Although fatigue is a well-known risk factor for traffic accidents (e.g. [3]), boredom remains a relatively unexplored area for driving safety research [25].

Boredom and cognitive load

The concepts of cognitive load and working memory [1, 34, 46] have also been examined in the context of driving safety, particularly in the Automotive User Interfaces domain. A person's cognitive load may not be sufficient to pay attention to all of the relevant stimuli in a driving situation. This is especially true if the person is paying attention to driving-irrelevant stimuli, such as their mobile phone (e.g. [28, 45]). However, although cognitive load relates to difficulties with attention - as does boredom - a person who has a low cognitive load is not necessarily experiencing boredom (see [22] for relevant discussion).

Similarly, a bored person may not have a low cognitive load. Rather, a discrepancy between what a person is thinking about and what they want to be thinking about, can lead to feelings of boredom [22] [13]. A young male who seeks a lot of mental stimulation while driving, but for whom 'safe' driving is relatively easy (i.e. low cognitive load), may feel bored and seek additional stimulation via unsafe driving behaviours.

Proneness to boredom

Researchers have suggested that boredom is a common experience (e.g. [13]). However, to date, only limited data exists on the prevalence of boredom. We can only speculate how today's increasingly ubiquitous personal devices will affect boredom proneness. Today, smart phones, for example, provide stimuli almost wherever we go, whenever we want - except in the car, legally, but practically, even in the car [6]. We could further hypothesize that through the increased availability of stimuli from early childhood, people's boredom proneness may increase in the future. To our knowledge, there has been no research that specifically supports this hypothesis. However, this possible increase of proneness to boredom is indeed plausible, and could therefore potentially increase safety risks if it is not addressed.

DESIGNING AGAINST BOREDOM IN THE CAR

Above, it was established that: 1. Young male drivers are prone to boredom. 2. Their need for stimulation is hardwired and may not be modifiable. 3. Boredom may lead to risky driving behaviour. And 4. Existing strategies to reduce young males' risky driving are conceptually flawed and ineffective. Consequently, there is a logical and urgent need to find innovative ways to provide alternative stimuli while driving when needed and when it is safe to do so. This is illustrated in Figure 2, which shows an intervention providing stimuli in a way that alleviates the state of boredom and therefore eliminates the associated risk taking behaviour (c.f. Figure 1).

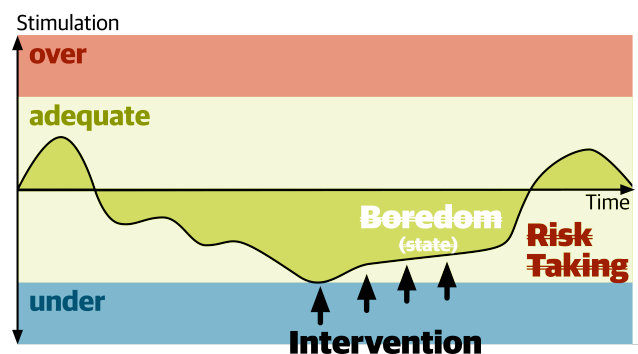


Figure 2: Designing interventions against boredom

At the core of this research lie the following questions:

- How can innovative technologies and interventions be designed to make safer driving behaviours equally or

more pleasurable and stimulating than risky driving behaviours?

- Can the alternative stimuli be designed in a way that they replace seeking risky driving stimuli, hence reducing risky driving?

We propose the exploration of what we see as the only two logical approaches or concepts to achieve this. The two concepts are innovative in that they represent a paradigm shift: They are neither oblivious to road safety risks nor are they using a patronizing approach by telling young male drivers what not to do without offering them an alternative to satisfy their need.

CONCEPT A: SIMULATING RISKY DRIVING BEHAVIOUR THROUGH IN-CAR AUGMENTED REALITY

This concept involves translating real-world stimuli that convey risk into augmented reality stimuli that convey risk, i.e. giving drivers a sense of speed or risk without an actual increase in speed or risk. Drivers will experience some of the stimulation associated with taking a risk even though they are not actually taking a risk. This can be achieved in two ways:

1. Changing car features so that it appears faster or more risky to drive, when it is safe to do so. This is further illustrated by the following real-world example: Some young drivers seek the thrill for speed and the roar of the engine. Exhaust modifications to their cars increase the thrill of the roar and make the car feel faster than it actually is.

2. Changing the road environment so that it appears more risky, challenging or stimulating to drive, when it is safe to do so. There have been promising results in the civil engineering domain, e.g. creating shared spaces for pedestrians, cyclists and cars in urban environments [23]. Research on monotony and driver fatigue encourages environmental countermeasures such as placing visual elements along the road to disrupt monotony [47].

This paper proposes to achieve these changes to the car features or the road environment through technologies such as augmented reality, digital sounds, etc. An example to illustrate this is a virtual optical lens effect that alters the environment in a way that makes it appear to pass by faster or by adding virtual vehicles through HUDs that are being passed quickly when there is not much traffic. The benefit of using digital technologies is that they are potentially more effective because they can be tailored to the individual's needs and current context (e.g. location, driving situation).

Overall, this concept leads to the following two research questions to guide future research:

- *How* can technologies be designed to alter or augment the reality of a boring task to digitally simulate the thrill of risky driving behaviours?

- Does the digital simulation of greater speed or risk reduce risky driving behaviours?

In summary, this concept allows young adults to respond to boredom by either actively taking artificial risks instead of actual risks (basically a mix of Figure 1 and Figure 2, where the intervention provides artificial risk when risk is sought) or being presented with a higher artificial risk than real risk (Figure 2). However, the stimuli are *risk*, rather than other stimuli, which form the basis for the second concept, described in turn.

CONCEPT B: TREATING BOREDOM BY SAFELY PROVIDING STIMULI WHEN NEEDED

This concept follows the hypothesis that providing safe, driving-related and pleasurable stimuli through digital technologies in the car can replace the urge for risky driving behaviours in young male drivers. The theoretical grounding is based on the premise that these additional stimulations can break drivers' boredom, hence diverting their attention back towards the safe driving task and away from seeking stimulations through risk taking. Overall, this as yet unexplored concept articulates the notion of pleasure and safety in one technology intervention with the view to reduce injuries and fatalities.

Conceptually, this approach is similar to the Australian Government's "Swap It! Don't stop it!" campaign (www.swapit.gov.au), which encourages swapping bad habits with healthier alternatives, or the Volkswagen Fun Theory initiative (www.thefuntheory.com), which presents ideas that make good behaviour more pleasurable or appealing than bad behaviour. For example, the Speed Camera Lottery rewards drivers complying with the speed limit with the chance to win a lottery that is financed by fines paid by speed offenders. By making good behaviour fun, this campaign reduced average speeds from 32 km/h to 25 km/h [42].

The hypothesis presented above leads to the following research questions for future research:

- *What* are driving-related and pleasurable stimuli for different driver archetypes, particularly boredom prone young males?
- *How* can new technologies be designed to safely provide pleasurable stimuli at the right time?
- Do pleasurable stimuli have safety benefits by replacing the urge for risky driving behaviours?

The concepts of pleasure and safety have conventionally been portrayed to pull apart from each other. Car manufacturers and the research community around Automotive User Interfaces aim to unite the pleasure of driving and road safety by focusing on the question as to how a driver can safely interact (output/input) with various types of data or information without causing driver distraction.

The question of *how* to safely output or input information undoubtedly pushes technological advancements, making in-car Human-Machine (HMI) and Human-Computer interaction (HCI) safer. However, the '*How*' is only part of the solution. The actual information or applications (the '*What*') that form the basis of in-car HMI/HCI research have not changed much in recent years. They generally include tasks such as writing/reading SMS, emails, or more recently tweets and social media status updates; dialling or making phone calls, selecting from lists of the in-car entertainment system; operating the navigation system; or, exploring points of interest.

Little attention has been paid to new types of content and applications. In particular, relatively little attention has been paid to whether some of the same traits and motivations that lead to sensation seeking and distraction can be harnessed to encourage safe driving.

One promising means of effectively encouraging safe driving in this way are the '*social car*' [41] concepts we developed through a pilot study [40] and evaluated in the road safety domain [39]. The other promising means, which we hypothesise to be particularly effective amongst our target group of young male drivers, is *gamification*, which we therefore elaborate in more detail as follows.

Gamification

Gamification is best defined as the use of game design elements in non-game contexts [9]. It is most commonly used where the goal is to create greater engagement, fun or motivation among users of a tool or interface. In recent years, gamification has been successfully applied as a design concept to enhance user experience and engagement in a variety of industries and domains, including productivity, finance, health, education, sustainability, news and entertainment media [10, 20, 35]. Reviews of gamification [21] [20] show that in the majority of applied cases gamification has a positive influence on the desired outcomes. The desired outcomes are most often improvements in engagement or motivation, increased awareness and greater enjoyment or fun. These outcomes are encouraged through a range of motivational affordances including visual or audio feedback; social support and comparisons; communication of progress; persuasive messages and reminders; objectives and goals; and rewards, credits, points and achievements [20].

Diewald and colleagues [11] reviewed the use of gamification (or 'gameful design') in the automotive domain. They found that gamification was primarily being used in vehicles for navigation, eco-driving and driving safety. In terms of driving safety they identified two existing applications - Driving Miss Daisy [43] and CleverMiles (<http://www.clevermiles.com/>). Driving Miss Daisy provides feedback to drivers on their driving performance and rewards them with virtual money. CleverMiles requires an external device and rewards safe

driving with points that can be redeemed for real products. However, neither application is specifically focused on questions of boredom, sensation seeking and associated risk among young male drivers. Here we propose a vision that applies gamification to road safety in order to stimulate drivers with engaging, driving related tasks when they are being under-stimulated by the current driving context, and to motivate them to drive more safely and courteously.

Specifically we are interested in the use of rewards to improve driving. Rewards in videogames have been identified as broadly falling into four categories; *glory*, *access*, *facility* and *sustenance* [19, 38]:

- Rewards of glory are those that have no impact on the gameplay itself, but provide the player with status or achievement. Examples include leader boards for high scores or trophies for achievements.
- Rewards of sustenance are those that allow the player to maintain their status quo in the game and keep objects acquired up until that point. Examples include health packs, potions and armour.
- Rewards of access allow the player to access new locations or resources that were previously unavailable to them. Examples include keys, passwords or new weapons.
- Rewards of facility allow the player to do things they could not do previously or to enhance existing abilities. Examples include the ability to jump higher or modifications to improve vehicles used in the game [38].

Examples

Identifying how to design these reward types into the driving context and exploring which road safety benefits they might have are key issues that need to be further investigated in the future. In turn, we provide examples to illustrate our point and provoke further thought, rather than to suggest them as actual solutions. Further, note that conceptually these examples are intended to make the driving task more active and engaging *only when* the current driving task does not provide enough stimuli, and where the intervention can be made without inadvertently substituting one problem for another (for example, increasing activity and engagement but distracting drivers from existing stimuli essential for safe driving). Future Intelligent Transport Systems will enable the type of evaluation of the current driving situation that would be required for such context aware applications.

The example depicted in Figure 3 illustrates rewards of glory in the driving context. It shows an augmented reality application that allows drivers to a) rate each other, b) accomplish safe driving related achievements by being rated and c) view each other's achievements. In this way, we provide the driver with a series of rewards of glory through positive feedback and aim to create a sense of competition in terms of the desired driving behaviours.

Adding such a layer of playful engagement obviously requires safe interfaces for inputting and outputting such information, but conceptually it could stimulate the driver with a playful, driving-related task that keeps them 'distracted' (in a good way) from other risky driving decisions, such as speeding.



Figure 3: Rating other drivers for rewards of glory

Other interesting applications of reward types are possible. For example, rewards of access might be implemented in terms of providing drivers with access to favoured applications (e.g. Facebook, twitter), when it is safe to do so, in return for safe driving behaviours such as constant safe speed and distance maintenance. Rewards of facility might also be incorporated in this way, for example offering a higher speed data connection for use of these applications in return for desired safe driving behaviours.

Alternatively, in the context of implementing playful, driving-related distraction tasks (such as that outlined in Concept A above), rewards of sustenance, access and facility could be implemented. Drivers could gain access to different 'levels' of the distraction task as they successfully reach a series of safe driving milestones, perhaps with increasing quality of the augmented car sound or differing visualizations for each level associated with the augmented road environment. During these tasks, rewards of facility could be incorporated in terms of the skills and abilities that the driver can use (for example, the ability to appear to pass virtual cars faster in the HUD). Rewards of sustenance might be incorporated in this setting by allowing drivers a notion of 'health' in the virtual setting, such that when attempting to exhibit target behaviours in the virtual HUD they are able to make one or two errors before 'failing' the level.

As mentioned, these present just a few examples to illustrate concepts that we hypothesize to work well within our target group of young male drivers. However, we will explore this innovative approach to road safety in more detail in the future. This exploration includes a) examining and expanding our understanding of the role boredom plays in relation to road safety, initially focusing on young males, b) designing and grounding possible technology interventions and applications in further research, and c) to test and scrutinize our proposed concepts in extensive advanced simulator studies. As demonstrated, the research

literature in the road safety, human computer interaction, gamification, and psychology domains provides the basis to pursue this vision in greater detail.

CONCLUSION

This paper presents the theoretical grounding from several domains of research towards a unique and innovative approach to an enduring and prevailing road safety problem: the overrepresentation of young, particularly male, adult drivers in the road toll [5].

This paper provides evidence from the psychology and road safety literature that points to young males' proneness to boredom, which is tightly coupled with their typical sensation seeking behaviour, as one of the factors influencing their road accident figures. It is important to note that we are not claiming boredom to be the only factor, nor are we able to quantify its contribution. Nevertheless, there is a plausible correlation that warrants further investigation, particularly in light of existing strategies failing to address the increased road safety threat of mobile phone use in the car. Despite this, boredom remains a relatively unexplored area for driving safety research [25].

Our contribution lies in inviting other researchers, particularly in the automotive user interfaces domain, to consider the concepts and research questions we put forward when implementing the next generation of in-car applications. Rather than demonizing ubiquitous computing technologies as a threat to road safety by distracting drivers, we see them as an opportunity of untapped road safety potential, e.g. by applying gamification techniques to the driving activity.

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