From Gearstick to Joystick – Challenges in Designing New Interventions for the Safety-Critical Driving Context

Fabius Steinberger[1], Ronald Schroeter[2], Verena Lindner[1]

[1]Urban Informatics Research Lab
Queensland University of Technology
Brisbane, Australia
fabius.steinberger@qut.edu.au

[2]Centre for Accident Research and Road Safety
Queensland University of Technology
Brisbane, Australia
r.schroeter@qut.edu.au

ABSTRACT
Consumer electronics increasingly find their way into cars and are often portrayed as unwanted distractions. As part of our endeavour to capitalise on these technologies as safety tools rather than safety threats, we suggest to use smartphones, head-up displays, vehicle interfaces, and other digital gadgets: a) as readily available and lightweight sensing devices, and b) as platforms for engaging interventions that provide safe stimuli in real-time while driving. In our effort to make safe driving behaviours more fun, we explore ways to apply gamification to driving. In this paper, we illustrate the need for a careful balance between fun and safety and reveal ethical issues that arise when introducing new technology interventions into this complex and safety-critical design space.

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Interaction design; gamification; road safety.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
This study is situated at the intersection of human-computer interaction and road safety. It addresses risky driving in young males, who are overrepresented in road accidents (WHO 2013), score high in sensation seeking behaviour (Zuckerman et al. 1978), and are prone to feeling bored (Drory 1982). In fact, sensation seeking and boredom proneness are directly correlated (Zuckerman 1994). That is, a lack of stimulation while driving can lead particularly young males to feeling bored. This feeling may trigger the seeking of sensations (e.g. speeding) or distractions (e.g. mobile phone use), which in turn can lead to accidents. We therefore follow the argument that making safe driving more fun, engaging and less boring can have road safety benefits (Schroeter et al. 2014). Added workload and distraction have received extensive attention in the road safety context, whereas under-stimulation and boredom have not.

Risky Gadgets to the Rescue
Designing new safety interventions to combat boredom poses the question which technology platforms to use. Young people tend to purchase used cars and therefore have limited access to modern in-vehicle information systems. In fact, statistics show the average age of all vehicles registered in Australia is approximately ten years. Our research hence focuses on options available to young drivers today with a view to have maximum and more immediate road safety benefits.

The product life cycle of consumer electronics, unlike cars, does usually not exceed a few years, and both hardware and software are typically updated every year. Irrespective of their intended use, smartphones and other devices will unavoidably be present in the car as people carry their gadgets with them. Furthermore, there has been a significant increase in drivers reporting use of social media and smartphone apps in the car, especially among young people. Regardless of punitive strategies, new consumer electronics will continue to be used within the car, especially by young males, who, in addition to being prone to boredom are typically early adopters of such technologies. Young drivers are therefore likely to have access to stand-alone gadgets much sooner than they do to the tailored in-vehicle information systems mentioned above. In addition, consumer electronics have increasingly sophisticated sensing, networking, and output capabilities. They thus provide an ideal platform that we intend to capitalise on.

We begin by reviewing related work on sensing technology and approaches to influence driving behaviour. We then discuss ethical issues related to procedural requirements as well as issues emerging from the research trajectory itself. Designing interventions for a complex and safety-critical context such as the driving context also means carefully considering potential risks that arise from introducing new technologies. We then present our design process and put forward novel ideas on how to potentially leverage consumer electronics as a road safety tool rather than a threat. This allows us to formulate preliminary designs of novel application concepts that aim at making mundane driving scenarios more engaging. In participating in the workshop on ethical encounters we hope to discuss ethical considerations early on and include them into our design process.

RELATED WORK

Consumer electronics such as smartphones, tablets, or fitness trackers provide an untapped safety potential. First, their built-in sensors can be used for sensing data and driver state detection; and second, they can be capitalised for safety interventions to influence driving behaviour.

Sensing

There are three types of data for monitoring and providing feedback to drivers on their on-road behaviour: 1) driver data (driver state, mental and physiological conditions, etc.); 2) vehicle data (location, direction, speed, acceleration), and; 3) environment data (following distance, traffic situation). Highly accurate and reliable sensing platforms are heavyweight and expensive and are neither suitable nor affordable for timely mainstream deployment. In turn, we discuss a wide variety of sensors available today in consumer electronics that researchers have started exploiting in recent years for each data category.

Driver data. Fitness trackers and smart watches provide information such as heart rate activity and whether the user is seated or not. Smartphones and tablets allow for real-time camera image and audio processing. Action cameras could potentially extend these capabilities, e.g., to detect fatigue using blink detection algorithms (You et al. 2012; Schroeter et al. 2013). The Drive Awake smartphone app and the stand-alone device Anti Sleep Pilot are commercial products aimed at detecting fatigue.

Vehicle data. Smartphones have previously been utilised to detect speeding violations (Eren et al. 2012) and drunk driving patterns (Dai et al. 2010). Bluetooth connectors for on-board diagnostics (OBD), which are available at a cheap price (less than 50 AUD), complement this set of information. Paired with a smartphone, they allow anybody to display accurate data such as current speed or fuel intake. On-board diagnostics (OBD) dongles such as Automatic track and visualise data in their respective smartphone apps, offering location information to family members and coaching features to improve driving skills.

Environment data. Data about the driving environment can be derived from camera imagery. This method has previously been trialled to identify collision danger or traffic signals (Koukoumidis et al. 2012). Crowdsourcing data (e.g., traffic light schedules) can facilitate novel applications and benefit drivers by saving fuel or recognising changed road conditions.

Interventions to Influence Driving Behaviour

Previous work has explored technology to facilitate safer driving behaviours Coben et al. (2013) suggest technological capabilities should be used to render phones inoperable while the car is in motion in order to mitigate the risks of driver distraction. Indeed, in a review of smartphone apps targeted towards drivers (and available in 2014), Rodríguez et al. (2014) identified that most of the apps restrict access to texting or calling functionalities. However, we argue that many drivers will not voluntarily cease using their phones but rather continue to bring new and more consumer electronics into the car. Our intention therefore is to complement existing road safety strategies by leveraging those devices as safety tools in a way that is more accepted by users.

We are not alone in this way of thinking. Rather than fighting phone usage, a number of apps aim at improving driving behaviour using gamification elements. For example, Axa Drive rewards good driving behaviour through points and allows users to share their accomplishments with their social networks. Similar concepts include VW Smile Drive, and Samsung S-Drive. However, these apps will only offer insights after a drive has been completed and therefore, unlike our approach, will not address driving behaviour in situ and real-time. Other related approaches will provide feedback during the drive, however, without taking into account when it is safe to do so (Ecker et al. 2011; McCall and Koenig 2012; Shi et al. 2012). As a consequence, they become distractions themselves. We explore concepts that make mundane driving situations more exciting when needed and potentially result in beneficial flow on safety effects. That is, when drivers choose to use our tools to combat boredom, they will be challenged to drive in a safe manner.

ETHICAL CONSIDERATIONS

Human-centred design involves the intended user at all stages. As part of this approach, we conducted interviews and workshops with young males to gain an understanding of their practices and mindsets during boring drives. This would have potentially led to participants talk about their illegal driving behaviours. We had therefore put in a high-risk application, which dealt with the de-identification of the data, for acquiring ethical clearance from the university's ethics committee. What are other ethical considerations to look out for when interviewing about potentially law-breaking ways of acting? How can we, as researchers, best cope when exposed to sensitive information?

Another ethical issue to discuss is our design direction itself. Games usually do not have serious consequences. Gamification might simplify complex processes for a better experience, which may lead to careless or irresponsible behaviour. Do gamification concepts trivialise something serious such as road safety?

Related to the above is a concern with respect to deploying our interventions. We can manage disruption as long as we run studies in the driving simulator. However, how can we anticipate implications in the real driving environment, which is much more complex?

LEVERAGING CONSUMER ELECTRONICS AND GAMIFICATION IN INNOVATIVE WAYS

In the following sections, we will discuss how we created preliminary design ideas that leverage consumer electronics as safety tools.

Video Games Review

To inspire the design process, a review of video games was conducted. In order to explore how video games keep players engaged in driving related activities, we looked into games from a broad spectrum of genres. We then focussed on high rated games (to limit scope) and sought

innovative gameplay concepts. Our final selection contained simulation racing games like Forza Motorsport 4, arcade influenced games such as MotorStorm Apocalypse, and non-naturalistic games like Mario Kart. In addition, we investigated open world adventure games that incorporate driving elements, such as Grand Theft Auto 5. In total, fifteen games were reviewed.

Most driving related video games rely on fast reaction times as well as arcade mechanics like shooting or hitting other cars, and are visually demanding and therefore distracting. Transferring those characteristics into the real driving context would obviously defeat the purpose of safer driving. Some games (e.g., Dirt 3, Forza Motorsport 4), however, include challenges blending driving activities with other fun, playful activities such as bowling. Inspired by these typically short games, we a) replaced "bad" driving behaviours with "good" driving behaviours; and b) chose particularly mundane driving scenarios as context. Figure 8 shows an early concept sketch, which adopted the activity of bowling to the driving task of coming to a stop at a traffic light. Further refined, it inspired the pilot prototype.

In an iterative, scenario-based design approach, the multidisciplinary design team members claimed the roles of the story keeper, experience designer, and developer (inspired by Löhmann 2014). As such, they scrutinised every concept based on the feasibility, fun and, most importantly, safety criteria. In the next section, we will discuss one of these concepts as an illustrative example.

Traffic Light Game

Applying gamification design in the safety critical space of the car requires a careful balance between fun and safety (Steinberger et al. 2015). For this initial game, which is work in progress, we picked the mundane driving scenario of approaching a traffic light. It represents a common driving activity, that is, coming to a stop. We adapted the smartphone game Angry Birds to make this task more engaging and fun. Contrary to Angry Birds, the target in our game concept is a bull's eye. It visualises the driver's performance when coming to a stop based on data gathered as described earlier. It takes parameters into consideration such as the smoothness and consistency of braking and steering as well as the distance to the traffic light or car in front. As such, it illustrates how a mundane driving task can be turned into a more exciting activity.

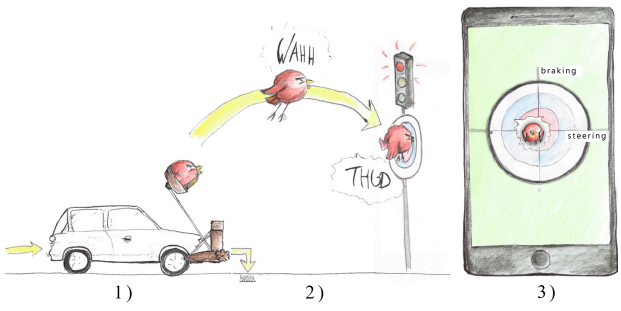

Figure 1: The Traffic Light Game.

Figure 1 shows a scenario sketch of this game depicting three phases. The first phase is equivalent to the player tautening the sling in the original game, which determines the trajectory of the bird's flight path. It starts when the smartphone detects an approaching red light. At this point, the screen does not display any information to avoid distractions. 90% of the driving task is visual, so the design goal is to keep additional visual information to a minimum in this phase. Instead, audio cues make the driver aware that the mini game has started.

The second phase begins when the car is coming to a complete stop. The bird then flies in an animated fashion towards the target emitting an entertaining battle cry for the driver. In the third phase, the bird hits the target. A sound hints at what happened, and the driver receives additional visual feedback on the screen, which is now safe. Nevertheless, the background colour adapts according to the driver's performance (faded being bad, highly saturated being good) so that the result can be conveyed in their periphery. The bird positioned on the bull's eye represents more detailed information regarding smoothness of braking (y-axis) and steering (x-axis) so that drivers can improve on their next approach.

Implementation

We are currently testing an Android prototype for this concept, which was implemented at the core layer without the Angry Birds theme. One challenge is to determine when to activate the game. As it is difficult to detect boredom reliably at this point, we will allow drivers to activate the game themselves whenever they feel the need to do so. Drivers already decide themselves to do distracting tasks in mundane driving situations.

CONCLUSIONS

In our effort to make safe driving behaviours fun, we explore ways to turn the car into a game controller. Specifically, we propose to leverage readily available consumer electronics such as smartphones as road safety tools. We aim to provide stimuli during a mundane driving task and keep young, male drivers engaged and less bored, which we argue may have safety benefits. The main design challenge is considering the road safety constraints in this sensitive and safety-critical design space. Rather than simply applying gamification, it is vital to carefully scrutinise every idea from a road safety psychology perspective. This requires collaboration across interaction design, road safety, software development, and video game theory. We will refine, develop, and evaluate prototypes in future empirical studies. As the expected outcome, this will deliver new insights for the design of safe, driving related stimuli.

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