Accident Analysis and Prevention 137 (2020) 105412

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

"It is frustrating to not have control even though I know it's not legal!": A mixed-methods investigation on applications to prevent mobile phone use while driving

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ARTICLE INFO

Keywords:
Cell phone
Ergonomics
Human-machine interactions
Inattention
Driver behaviour
UX

ABSTRACT

Mobile phone distracted driving is a major risk factor for crashes. However, this behaviour has been increasing in recent years. Effective enforcement of mobile phone bans while driving faces several obstacles; as such, it is important to consider additional countermeasures. Applications designed to prevent distracted driving are a promising solution, yet more research is needed that examines their effectiveness in reducing dangerous phone use while driving behaviours. Additionally, these applications are voluntary in nature; therefore, an understanding of drivers' perceptions of the applications is necessary to determine how to improve uptake. A mixed methods design was utilised to examine these factors in a comprehensive manner. A total of 40 participants used the smartphone application "Do Not Disturb While Driving" for iOS phone operating systems or "Android Auto" for Android phone operating systems for approximately one week and completed three diary entries reporting on their experience. Two questionnaires that examined phone use while driving behaviours were also administered to participants; one before and one after completing the study. The quantitative results found that engagement in 1) visual-manual, 2) cognitive-auditory and 3) music mobile phone interactions significantly decreased while using the application. Distraction engagement and mental workload while driving also significantly decreased while using the application. The qualitative results identified a number of areas of improvement that need to be addressed, e.g. activation of the application and Bluetooth connection reliability. The features that required improvement presented an obstacle for effective use of the applications, and in some cases resulted in drivers deciding to stop using the application. Positive perceptions of the application were associated with the experiences of the application functioning appropriately and activating automatically. These results show that applications designed for voluntary use to prevent mobile phone distracted driving are a promising countermeasure, although current applications require several improvements.

1. Introduction

Mobile phones (or cell phones) are ubiquitous devices. Research has shown that problematic mobile phone use, including mobile phone use while driving, has increased in the last decade due to growing affordability and usability (Oviedo-Trespalacios et al., 2019a; Huemer et al., 2018). Mobile phone use while driving has detrimental effects on driving performance, including an increase in reaction time (Collet et al., 2010; Lipovac et al., 2017; Svenson and Patten, 2005; Oviedo-Trespalacios et al., 2016) and poor vehicle control (Lipovac et al., 2017; Oviedo-Trespalacios et al., 2016; Caird et al., 2014; Collet et al., 2010; Li et al., 2019; Haque et al., 2016; Svenson and Patten, 2005). It also decreases driving performance not only during the task but on average for another 3.38 s after completing the phone task (Thapa et al., 2014). These findings highlight the importance of creating effective countermeasures that reduce mobile phone distracted driving.

Voluntary applications designed to prevent mobile phone distracted driving are a promising countermeasure for mitigating this risky behaviour. As legal bans of phone use while driving have shown to be largely ineffective (Jessop, 2008; Nevin et al., 2017; Oviedo-

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https://doi.org/10.1016/j.aap.2019.105412
Received 16 November 2019; Accepted 23 December 2019
Available online 29 January 2020

Trespalacios, 2018; Rudisill et al., 2018; Ehsani et al., 2014; Foss et al., 2009; Goodwin et al., 2012), targeting phone use while driving with an application appears to be a promising solution. Such applications disable specific phone functions such as messages and calls, and in some cases enable other phone functions that are instrumental to the driving task such as global positioning system (GPS) applications. However, very little is known about how drivers interact with these applications and the effectiveness of such applications.

Initial investigations into these types of applications have found partial support for their effectiveness in reducing mobile phone distracted driving. A content analysis of the current voluntary applications designed to prevent mobile phone distracted driving identified that this intervention is promising due to its potential to reduce exposure to visual-manual phone tasks while driving (Oviedo-Trespalacios et al., 2019b). A recent study by Albert and Lotan (2019) monitored phone touches while driving among young adults in Israel both before and during the time that these drivers used a researcher designed application that 1) blocked notifications and 2) sent an automatic reply to the individual who was trying to contact the driver. It was found that phone touches were reduced by approximately 20 % when participants were using the application, providing support that these applications can mitigate some dangerous phone use while driving behaviours. This early evidence suggests that these applications can play a useful role in distracted driving prevention if correctly integrated, which makes them worthy of further research.

A limitation of these applications is their voluntary nature. Therefore, it is important to consider their acceptability and adoption (Oviedo-Trespalacios et al., 2020). A U.S. study found that the psychosocial variables of attitudes, frequency in reporting texting and driving and the likelihood of engaging in this behaviour had minimal success in predicting continued engagement with a voluntary application designed to prevent mobile phone distracted driving (McGinn, 2014). Meanwhile, an Australian study found that fleet drivers had negative attitudes towards applications that block phone functions while driving (Ponte et al., 2016). A U.S. study targeting young drivers found that only 54 % of young drivers believe that automatic phone locking is an effective way of stopping mobile phone use while driving (Delgado et al., 2018). Lastly, cross-sectional studies in Australia and the U.S. found that nearly two years after iOS and Android released their applications to prevent distracted driving (i.e., Do Not Disturb While Driving and Android Auto), their adoption has been extremely limited in both countries (Oviedo-Trespalacios et al., 2019c; Reagan & Cicchino, 2018). These results identify that barriers for using the applications need to be further investigated.

1.1. The current study

Applications designed to prevent mobile phone distracted driving are seen as a promising countermeasure. However, more research is needed to 1) determine their effectiveness in reducing distracted driving and 2) determine barriers for the adoption of these applications. Consequently, three research questions were considered for this study:

- Research Question 1: Does using the application reduce driver's engagement with mobile phone distracted driving?
- Research Question 2: What are drivers' experiences with the application?
- Research Question 3: What functions of the application need to be improved?

2. Method

2.1. Procedure

This study utilised a longitudinal two-part questionnaire component (Quantitative) paired with three diary entries (Qualitative). As there has been limited focus in the area of voluntary applications designed to reduce mobile phone distracted driving, a mixed methods approach was selected as the best means to understand drivers' perceptions and interactions with the applications. The quantitative component (i.e., questionnaires) provides quantifiable data regarding mobile phone use while driving as well as other relevant information concerning driver characteristics and driving patterns. Meanwhile, the qualitative component (i.e., diaries) allows participants to report their experiences using the applications without restrictions.

All participants were recruited online via a combination of email recruitment and social media advertising. Participant selection criteria included: 1) must be aged over 18 years, 2) have a current drivers licence, 3) own a smart phone and 4) drive in Australia at least 30 min per week. Before completing the study, participants who signed up were asked to download and familiarise themselves with the 'Do Not Disturb While Driving' or 'Android Auto' phone application, depending on their phone's operating system. Participants were told to use the application when appropriate. Additionally, participants were asked to watch a short YouTube video that provided instructions on how to use the corresponding application: https://www.youtube.com/watch?v=IhAIzc1MgVc (1 min 36 s) for 'Do Not Disturb While Driving' and https://www.youtube.com/watch?v=Ht8yzpIV9M0 (1 min 45 s) for 'Android Auto'.

At the beginning of the study, participants completed the first questionnaire. The order in which each subsequent component of the study was undertaken by participants, as well as the time periods between components, is presented in Fig. 1. Participants were told they must have driven at least 30 min without passengers before completing the next study component. Data collection occurred over an 8 week period. Participants received a $100AUD voucher for their participation. This study was approved by the University Human Research Ethics Committee.

2.2. Questionnaire component

Two questionnaires were utilised for this study. In questionnaire 1, demographic questions were asked, including age, gender, type of car, average hours spent driving per week, highest level of education, type of mobile phone operating system and crash history.

To examine engagement in mobile phone use while driving, 12 items were created to measure four different types of phone use while driving behaviours: visual-manual, cognitive-auditory, social media and games, and music. Most phone functions can be defined as either visual-manual or cognitive-auditory. While the 'social media and games' and 'music' phone functions can also come under these headings, they each involve different intentions and processes, and therefore they were separated to allow these behaviours to be examined individually. Each item was measured on a 7 point Likert-type scale ranging from 'never' to 'always'. In questionnaire 1, this set of items was asked about their engagement in each type of phone use while driving in the previous two weeks. In questionnaire 2, the items were asked about their engagement in each type of phone use during the time that they were using the application.

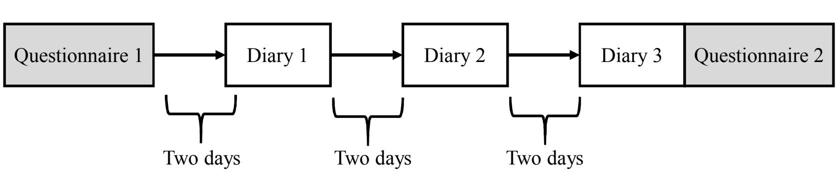

Fig. 1. Order and timing of each study component.

Table 1
Diary questions and prompts.

Diary questions and prompts
Describe your experience activating or deactivating the app (if you have not activated the app please explain your reasons). Did you make exceptions in the app?
Describe your experience using the activated app while you were driving
Describe the most significant problems while using the app, provide examples
Explain if the app makes driving any different
Describe your mobile phone use while driving
Explain if you needed something from the app and this was not available

Visual-manual phone tasks were measured with “You performed a visual-manual task on your mobile phone (e.g., texting, browsing, or emailing)”, “You looked continually at the phone for more than two seconds” and “You monitored/read conversations without writing back”. This construct had good internal reliability, with a Cronbach’s alpha of .76. Cognitive-auditory mobile phone tasks were measured with “You had a phone conversation using a hands-free device (e.g., headset or earphones)”, “You had a phone conversation using an in-car audio system or Bluetooth” and “You had a phone conversation without using your hands (speaker, earphones, others, etc.)”. This had acceptable reliability; $\alpha = .60$. Social media and games mobile phone tasks were measured with “You played games on your mobile phone”, “You posted on social media apps (e.g. Facebook, Twitter, Snapchat, etc.)” and “You used dating apps (e.g. Tinder, Grindr, etc.)”. This construct had good reliability; $\alpha = .70$. Finally, music mobile phone tasks were measured with “You initiated a music app”, “You searched for a song on a music app” and “You used your mobile phone to change songs”. This subscale had strong internal reliability; $\alpha = .88$.

The susceptibility to driver distraction questionnaire (SDDQ) developed by Feng, Marulanda and Donmez (2014) was used in both questionnaire 1 and 2. This questionnaire involves six subscales: distraction engagement, susceptibility to involuntary distraction, attitude, perceived control, perceived social norms 1 and perceived social norms 2. Distraction engagement was measured by 7 items covering the frequency with which participants engage in distracting behaviour while driving. For example, items state “When driving, you hold phone conversations” and “When driving, you read roadside advertisements”. This subscale had good internal reliability; $\alpha = .79$. Susceptibility to involuntary distraction consisted of 8 items and measured participants’ ability to suppress irrelevant distractions to driving; this was shown to have good internal reliability with $\alpha = .74$. Examples of statements include “While driving, you find it distracting when your phone is ringing” and “While driving, you find it distracting when day-dreaming”. Attitude consisted of 6 items and examined drivers’ attitudes towards distracted driving behaviours, with a higher score indicating more favourable attitudes towards driver distraction. This subscale had acceptable reliability, $\alpha = .54$. For example, statements include “You think it is alright for you to drive and manually interact with a phone (e.g., sending text messages)” and “You think it is alright for you to drive and chat with passengers if you have them.” Perceived control consisted of 6 items and examined perceived impact of distraction on driving performance. Examples of statements include “You believe you can drive well even when you manually interact with a phone (e.g., sending text messages)” and “You believe you can drive well even when you continually check roadside accident scenes if there are any”. Perceived control had good reliability, $\alpha = .70$. Perceived social norms 1 consisted of 6 items and examined perceptions of other drivers’ distraction engagement. Examples of statements include “Most drivers around me drive and read roadside advertisements” and “Most drivers around me drive and hold phone conversations”. This had good reliability, $\alpha = .90$. Perceived social norms 2 was made up of 6 items and examined participants’ beliefs about others’ approval or disapproval of engagement in distractions. For example, statments include “Most people who are important to me think it is alright for me to drive and adjust the settings of in-vehicle technology (e.g., radio channel or song selection)” and “Most people who are important for me think it is alright for me to drive and chat with passengers if there are any.” This subscale had good reliability, $\alpha = .75$.

The NASA task load index (NASA TLX) by Hart (1986) was also used in both questionnaire 1 and questionnaire 2. In questionnaire 1, participants were asked: “For the following set of questions please refer to driving in general.” In questionnaire 2, participants were asked: “For the following set of questions please refer to driving while using the phone application.” The task load index was measured on a scale of 1 (low) to 100 (high). The NASA TLX includes questions to measure mental demand, physical demand, temporal demand, performance, effort, and frustration.

2.3. Diary component

The quantitative diary entries asked participants 1) “How many hours have you driven since the last time you completed a diary (or questionnaire)?”, 2) “What percentage of your driving time was during the night?”, 3)” What percentage of your driving time was during peak hours?” and 4)” What percentage of your driving time was the application activated?” The qualitative diary questions are presented in Table 1. Participants were encouraged to provide examples when answering each question.

2.4. Data analysis

The questionnaire component was analysed using descriptive and inferential statistics. Means (including standard deviations), correlations and proportions were calculated and reported when needed. Paired *t*-test comparisons were conducted between the responses to questionnaire 1 (before) and questionnaire 2 (after). Data analysis for the diary component utilised an inductive approach, which allows new themes to emerge as opposed to restricting data to pre-defined categories (Clark et al., 2015). The data was analysed using the six phases of thematic analysis defined by Braun and Clarke (2006) and updated by Clarke et al. (2015). Data collection was terminated when no new codes were created, meaning data saturation was reached (Hancock et al., 2009; Mason, 2010).

2.5. Participants

A total of 40 participants completed the study. Participant ages ranged between 18 and 56 years (M = 31.6 years, SD = 8.6 years), and there were 24 (60 %) females and 16 (40 %) males. Average hours driven per week by participants, licence type and type of vehicle is presented in Table 2.

In total, 27 participants (67.5 %) had been involved in a crash at some point during the entire time they have been driving, while 13 participants (32.5 %) had never been involved in a crash. During the

Table 2
Average hours driven per week, type of licence and type of vehicle.

	Frequency
Average hours driven per week	
Up to 5 h per week	14 (35 %)
6 – 10 h per week	19 (47.5 %)
11 – 20 h per week	6 (15 %)
21 – 30 h per week	1 (2.5 %)
Licence Type	
Open Australian licence	26 (65 %)
International licence	9 (22.5 %)
Provisional Australian licence	5 (12.5 %)
Vehicle Type	
Small/medium vehicle	30 (75 %)
Large/SUV/utility vehicle	10 (15 %)

past 3 years, 10 participants had been involved in 1 crash, and 3 participants had been involved in 2 or more crashes.

Problematic phone use in general (not just while driving) was measured on a 10 point scale (Oviedo-Trespalacios et al., 2019c), with a score of 10 indicating very high problematic phone use. Participant mean scores ranged between 1.67 and 8.22. The overall mean score was 4.18 with a standard deviation of 1.53.

In relation to phone operating systems, 23 participants (57.5 %) owned an iOS device, meaning they used 'Do Not Disturb While Driving' during the study, and 17 participants (42.5 %) owned an android device, meaning they used 'Android Auto' during the study. Before beginning this study, only 18 participants (45 %) had heard about applications designed to reduce mobile phone distracted driving. A total of 5 participants (12.5 %) had experienced using this type of application before beginning this study. Of those participants, 4 reported intermittently still using the application.

3. Quantitative results

3.1. Mobile phone use while driving

The reported frequency of engagement in each type of phone use while driving behaviour both before and after experiencing using the application, as well as the associated *t*-tests are reported in Table 3.

Participants' reported visual-manual, cognitive-auditory and music mobile phone use while driving significantly decreased from time 1 (before) to time 2 (after). Meanwhile, there was no significant change between time 1 (before) to time 2 (after) for reported use of social media and games while driving. Correlation tables for the four different types of phone use while driving at time 1 (before) and time 2 (after) are presented in Table 4.

3.2. Susceptibility to driving distraction (SDDQ)

The means, standard deviations and *t*-test results for susceptibility to driver distraction are presented in Table 5. The difference in attitudes, control, social norms 1, social norms 2 and susceptibility to involuntary distraction between time 1 (before) and time 2 (after) were not significant. However, reported distraction engagement significantly decreased from time 1 (before) to time 2 (after).

3.3. Workload (NASA TLX)

The means and standard deviations for perceived workload while driving at time 1 (before) and time 2 (after), as well as the *t*-tests are presented in Table 6. Reported mental demand was found to significantly decrease from time 1 (before) to time 2 (time 2), suggesting that using the application decreases the mental demand of driving. Meanwhile, participants reported physical demand, temporal demand, performance, effort and frustration did not significantly change between time 1 (before) and 2 (after).

Table 4
Correlations between types of phone use while driving at time 1 (before) and time 2 (after).

	Visual-manual	Cognitive-auditory	Social media and games	Music
Time 1 (before)				
Visual-manual	1	.152	.132	.610**
Cognitive-auditory		1	.160	.077
Social media and games			1	.350**
Music				1
Time 2 (after)				
Visual-manual	1	.231	.464**	.757**
Cognitive-auditory		1	.051	.022
Social media and games			1	.402**
Music				1

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 5
Differences in the susceptibility to driver distraction questionnaire.

	Before *M (SD)*	After 2 *M (SD)*	t	Cohen's *d*
Distraction engagement	3.40 (0.73)	3.21 (0.73)	2.78**	0.45
Susceptibility to involuntary distraction	2.76 (0.63)	2.78 (0.62)	−.131	0.04
Attitude	3.07 (0.35)	3.08 (0.70)	−.251	0.02
Control	3.11 (0.72)	3.15 (0.66)	−.488	0.08
Social norms 1	4.03 (0.59)	3.89 (0.69)	1.64	0.26
Social norms 2	3.28 (0.70)	3.17 (0.65)	0.86	0.14

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 6
Differences in perceived workload between driving without the application at time 1 (before) and driving with the application at time 2 (after).

	Survey 1 *M(SD)*	Survey 2 *M(SD)*	t	Cohen's *d*
Mental Demand	68.23 (21.08)	55.73 (25.44)	3.90***	0.64
Physical Demand	36.60 (23.58)	33.43 (20.34)	1.02	0.13
Temporal Demand	45.83 (23.00)	45.40 (22.53)	0.13	0.02
Performance	84.53 (11.92)	85.60 (10.33)	−0.64	0.10
Effort	48.26 (24.19)	42.48 (21.94)	1.66	0.26
Frustration	30.13 (24.47)	31.95 (24.93)	−0.52	0.08
Total	313.58 (72.06)	294.58 (80.72)	2.31*	0.36

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

4. Qualitative results

4.1. Driving behaviour during the diary study

After completing the first survey and prior to completing diary entry 1, participants drove 4.48 h on average ($SD = 5.48$). Between completing diary entry 1 and diary entry 2, participants drove an average of 4.68 h ($SD = 4.57$) and between completing diary entry 2 and diary entry 3, participants drove on average 4.40 h ($SD = 5.96$). In sum, participants drove an average of 13.56 h during the study. On average,

Table 3
Differences in reported phone use while driving.

Reported Mobile Phone Use while Driving	Before *M(SD)*	After *M(SD)*	t	Cohen's *d*
Visual-Manual	2.76 (1.25)	1.90 (1.02)	4.38***	0.68
Cognitive-auditory	3.62 (1.43)	2.69 (1.51)	4.32***	0.68
Social media and Games	1.15 (0.64)	1.04 (0.13)	1.25	0.20
Music	3.08 (1.67)	2.26 (1.69)	3.89***	0.61

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

out of the time spent driving during the study, 25.27 % (SD = 18.55) of the time was spent driving at night, 43.12 % (SD = 21.44) was during peak hours and the application remained active 71.83 % (SD = 30.32) of the time.

4.2. Self-reported experience while using the applications

A total of four main themes were determined from the diary responses: 1) experiences with mobile phone use while driving while using the application, 2) activation of the application, 3) usability and 4) behavioural adaptations to the application. The results section is organised by themes, and direct quotes from participants are included in tables.

4.2.1. Theme: experiences with mobile phone use while driving while using the application

Participants reported on their experiences with mobile phone use while driving when using the application. A major concern associated with phone use while driving when using the application was that it could create more distraction in comparison to using the phone while driving without the application. This was reported when the application would not allow specific features; therefore, to access the desired phone feature, the driver would be required to engage in longer interactions with the phone such as deactivating the application (Table 7, quotes *i-ii*). Furthermore, participants also reported they felt the application provided additional distraction when they needed to switch between features because it changed the display layout (Table 7, quote *iii*). This shows that, due to the voluntary nature of the application, when desired phone functions are not allowed, drivers are also unlikely to continue using the application. In addition, the lack of familiarisation with the application can result in additional distraction.

An additional issue that resulted in mobile phone use while using the application was privacy. Before the application can be activated, a pop-up message is displayed asking the user to give permission for the application to have access to their phone. This permission made some participants uncomfortable, and as a result, they decided to deny permission for the application to control certain functions such as messages and calls (Table 7, quote *iv*), which limited the effectiveness of the application. It is possible that the privacy concern would act as a deterrent to using the application for some drivers. More transparency on the information collected by the application is needed.

As the application provides restricted access to phone use while driving, it was reported that the separation from the phone functions the driver normally accessed caused some concern. Specifically, one participant reported feeling anxious that they would not be able to read messages while driving, especially on long trips (Table 7, quote *v*). Another participant stated a problem they found was the inability to receive updates relevant to the road trip (Table 7, quote *vi*). Others simply reported they did not like the lack of control over their phone while driving, despite this behaviour being illegal (Table 7, quote *vii*).

Conversely, other participants found the application resulted in a positive separation from the phone. It was identified that the application allowed these participants to be less tempted to use their phones while driving (Table 7, quote *viii*). Using the phone while driving without the application resulted in the temptation to check text messages when they come through; therefore, having the phone blocked reduced temptation (Table 7, quote *ix*). Additionally, when feeling bored, it was reported that participants would be tempted to check their

Table 7
Selected quotes relevant to experiences with mobile phone use while driving while using the application.

Quotes	
i	If there is something I need to quickly check it makes it more cumbersome to do so and potentially more dangerous, because of the "I'm not driving" confirmation. I realise I shouldn't be doing this while driving but sometimes it isn't feasible to pull over. (M, 32)
ii	This time I wanted to pause the app at a stop to activate another app for the first time, but could not do it. The only possibility for me was to exit the app completely, work on the other app and then start Android Auto from scratch again. (F, 26)
iii	I feel that I'm more distracted with the app on, because I'm trying to switch things and I don't know where they are. (F, 27)
iv	The activation of the app is easy, but I did not like that it wants to have access to almost every function on my phone like calls, SMS etc., so I excluded them. (F, 28)
v	I felt very aware that I might receive texts/messages but not actually know about it. It made me feel a bit anxious and I had the need to reach over the check the phone. Since I was making a longer trip than usual today, this feeling of anxiety prompted me to keep my phone in the back and out of reach. (F, 35)
vi	Unable to receive changes to schedules such as "can you pick up milk" or "getting children from school late" (F, 34)
vii	I don't think there are any problems as such but it is frustrating to not have control even though I know it's not legal! (M, 28)
viii	I feel more focussed and less tempted to check on my phone. I actually drove with my phone in my bag on the bag seat, which is something I hadn't done in a while (F, 33)
ix	I think it's a good app to have because if I hear the text message come through I am tempted to look or pull over to read… most of the time if it's urgent a person will call me on the phone and I have Bluetooth in the car and can answer safely… it's text messages I believe that people will take their eyes of the road to read… even at lights etc so if you don't know you have a message then there is no temptation to read. (F, 56)
x	I do think that I'm becoming less distracted by the possibility of going to my phone in the case of being bored while driving. (F, 47)
xi	I did open my iPhone during several drives to change songs in my Music app. Overall I avoided making phone calls or sending text messages, which was a big difference for me. (M, 30)
xii	I still find it annoying that I have to say "I'm not driving" in order to access my Music app while driving. The main downside is that DND While Driving doesn't automatically reactivate when I close the iPhone again. (M, 30)
xiii	Not convenient to use Google Maps. If this app was activated and I want to use Google Map to go to a place I have saved, I have to exit this app. (M, 28)
xiv	I think the best contribution that the app has made is when I'm using the iPhone for GPS (Google Maps). Before I used DND While Driving, I used to get notifications which would come up over Google Maps at really inconvenient times (e.g. when I'm getting close to a complex navigation area) and it would be hard to see the navigation details. I couldn't fix this without having to reach to the phone and swipe the notifications away (which was temporary if I was getting multiple notifications at once, which happens sometimes).
xv	Used it to listen to music and used the GPS. Set up the music before I started driving. Used the OK Google detection to find directions while driving which I liked. (F, 43)
xvi	I didn't use my phone while driving. I connected it to head-unit before driving off and only accessed GPS and music via the head-unit before driving away (previously I would have done this while driving). Phone calls/text notifications came through when I stopped the car. (F, 35)
xvii	Don't use my phone as much anymore while driving. Can still make a call while parked then continue hands-free conversation while driving (F, 37)
xviii	Received phone calls. Same as before the app as it uses Bluetooth for phone calls. Asked google for directions and then asked some questions. This was very distracting as I was concentrating on asking questions and the responses rather than driving. (F, 43)
xix	Mostly did not use [the application] for short trips where I know the destination. Thus, I will pick it up to check messages or emails at lights that I am familiar with (knowing that they take some time to change). (M, 30)
xx	During the drive the app reminded me several times when I was subconsciously trying to access the home screen. This was always when I was waiting at a traffic light or waiting in a traffic jam, but I was happy to see the app working. (M, 32)
xxi	I don't use the phone while moving. I check messages when stopped at the lights but not now that I have the app (F, 42)
xxii	I have gotten better at not checking my phone to see who messaged me, since the app reads out the name of the sender and asks if I want to know the content of the messages. Before, I would look at my phone to see who messaged and sometimes read the message preview at the lights or when stationary. (M, 21)

Table 8
Selected quotes relevant to activation of the application.

	Relevant Quotes
i	I am activating my app before heading out, while I tend to deactivate the app on the way home due to forgetting to turn the app on. (M, 35)
ii	I usually activate the app straight away when entering the car after starting the music. I forgot to activate it once when I was not actively thinking about it. (M, 32)
iii	I often forget to activate the app because it is not habit. I have put a note on my steering wheel now to remind me to turn it on. I always remember to turn it off because I cannot do anything on my phone. (F, 26)
iv	I feel I have been slightly better with remembering to activate the app. It's like it's becoming more of a habit. I still haven't made any exceptions to the app. (F, 47)
v	I have to activate the app manually since I don't have a car that supports the apps automated activation feature as soon as it connects to your cars audio system. Therefore, sometimes I just forget or don't bother to turn it one because I already started driving. If it would be automated I'm sure it would be on 100 %. (M, 32)
vi	Worked out how to automatically sync the app to my car Bluetooth, so it automatically turns on when I enter and turn on my car and automatically turns off when I get out of the car. (F, 22)
vii	It's easy to use the app. I just chose 'automatically' when I activated the app. (F, 34)
viii	I found the app confusing to use, however I did not use my phone while I was driving and I think the app muted my message tone, so I did not hear my phone ring when I received a message (F, 18)
ix	It was easy to activate, no issues. (F, 18)
x	I did not activate the app for short trips, where I know the way, like to go to the supermarket. I used it only for slightly longer trips, where I actually needed navigation anyway, which means I would have used google maps normally. (F, 26)
xi	I turned the app off, because it was super annoying when I was trying to switch between songs. (F, 27)
xii	I've been activating and de-activating the app depending on how heavy the traffic is when I've been driving. Getting stuck at work meant getting stuck in peak-hour, and I get bored stuck in traffic. (F, 27)

phone while driving. However, as the application can block this, these participants reported no longer having that temptation to check their phone (Table 7, quote *x*).

When the application was active, participants still engaged in a number of visual-manual or cognitive interactions with their phones. The visual manual behaviours primarily consisted of 1) answering phone calls, 2) interacting with a navigation application (although, most of the time this was reported to be either visual and/or cognitive as they were primarily taking directions), 3) interacting with music (Table 7, quote *xi*), including starting a playlist, skipping songs, switching categories or adjusting the volume, 4) engaging in texting or messaging applications, 5) browsing the internet and 6) turning the phone's screen off to save battery power. Some problems were reported with accessing navigation or music applications. It was identified that some drivers were not able to easily open these functions whilst the application was active (Table 7, quote *xii*). Additionally, it was reported that, even if the navigation application works through the phone application, the specific navigation application Google Maps does not include saved places (Table 7, quote *xiii*). As such, they were required to use further visual-manual interaction by turning off the application used for the study, then opening their desired application. However, participants reported positive attitudes towards the application if the navigation application worked through the application as desired since the application blocked other pop up notifications that would otherwise come up over the navigation area, causing distraction (Table 7, quote *xiv*).

Cognitive phone interactions while driving included listening to music or podcasts, using Bluetooth for talking, and verbally requesting phone functions (either through Siri for iOS phones or through Google for Android phones) (Table 7, quote *xv*). Encouragingly, it was reported that some participants adapted their behaviour to avoid visual-manual phone interactions. For example, some participants reported starting up the music or GPS applications before driving so that they did not need to manually handle them when they started driving (Table 7, quote *xvi*). Another participant reported dialling when their car was parked, then driving once the visual-manual part of the phone task was completed and they could use Bluetooth to talk hands-free (Table 7, quote *xvii*). However, it was reported by one participant that the cognitive function of talking to Google distracted them from the driving task (Table 7, quote *xviii*).

The places in which participants reported using their phone while driving included 1) when stopped at a traffic light or 2) in slow moving traffic. The primary phone functions used in these situations involved checking a message, sending a message, or checking an email (Table 7, quote *xix*). However, the application stopped participants from doing this as it stopped message notifications and did not allow the driver to access these functions while driving (provided the participant set up the application that way) (Table 7, quotes *xx*- *xxi*). The application also reads out the name of the person who sends a text message and then asks the driver if they would like the message read out. This feature was reported to stop drivers from handling and looking at their phone (Table 7, quote *xxii*).

Overall, if the application was working correctly, it was found that participants were able to better manage their phone tasks while driving. While some participants did not have favourable opinions towards the separation from their phone, others found they enjoyed feeling less tempted to check their phone while driving. Cognitive phone interactions were able to replace some visual-manual phone functions while driving, which is very positive in terms of safety. However, it was consistently demonstrated that the application needed to work properly in order for the positive benefits of the application to be experienced.

4.2.2. Theme: activation of the application

Activation of the application is a crucial factor of its success, as difficulties with activation can mean that the user will not gain any of the potential benefits of the application. Overall, positive experiences with activation were associated with automatic activation. Meanwhile, participants who did not activate the application during a drive can be categorised into either 1) forgetting to activate the application or 2) intentionally deciding not to use the application. It was also found that some participants activate after beginning to drive if they initially forgot (Table 8, quote *i*) or deactivated the application while driving.

When the application did not start automatically, using the phone before driving was associated with remembering to manually activate the application (Table 8, quote *i-ii*). This occurred when participants were either using music applications or accessing navigation applications on their phone. The use of these phone functions immediately prior to driving increased activation of the application. Mostly, participants explained that manually activating the application is difficult to remember when they get in the car, as this behaviour is new to them and they are more focused on the drive ahead (Table 8, quote *iii*). However, after experiencing activating the application several times, participants reported it became easier to remember, and the behaviour became more habitual (Table 8, quote *iv*).

All participants who forgot to activate the system either decided to use manual activation as opposed to automatic activation or were simply unable to use automatic activation and consequently were forced to use manual activation (Table 8, quote *v*). Both Android and iOS phone users experienced automatic and manual activation. As such, the type of activation participants could use was not dependent on their

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phone and the specific application they were using, rather, it was dependent on their vehicle. Specifically, automatic activation was linked with the vehicle's Bluetooth connectivity.

Participants who reported automatic activation stated this occurred automatically after initial set up and when connected to Bluetooth. This automatic activation was considered an easy and efficient method for using the application (Table 8, quote *vi*). Some participants who activated the application also noted they did so to allow themselves to use their phone in a perceived safe manner while driving (Table 8, quote *vii*). It was also reported that some participants found the activation of the application confusing, yet still continued to use it (Table 8, quote *viii*). In later diary entries, these participants reported the activation became easier as they became more familiar with the application (Table 8, quote *ix*).

Conversely, a number of reasons were reported for intentionally deciding not to activate the application. Firstly, there were participants who avoided using their phone at all while driving and consequently would not use their phone to turn on the application when they entered their car. As the ultimate goal for these applications is to prevent dangerous distracted driving, this is an encouraging result. However, auditory notifications that have the potential to cause a distraction, for example via messages and calls, would not be blocked in these instances. Additionally, if participants were only driving a short distance, it was reported they did not consider that turning on the application while driving was necessary (Table 8, quote *x*). A common reason associated with using the application was to use a navigation application on the phone while driving, therefore driving to a well-known destination that does not require the use of a navigation application was stated as a further reason for not using the application. Another reason for deciding not to activate the application was potential conflicts between the application and other mobile phone functions. For example, it was reported that for some participants, the application prevented their ability to interact with music apps (e.g. skipping songs), which resulted in participants deciding not to activate the application in subsequent drives (Table 8, quote *xi*). Not surprisingly, a reason that was given to deactivate the application included the desire to use phone functions that are blocked by the application. For example, a participant reported they liked to use their phone if they were stuck in peak hour traffic, as such they would deactivate the application when stuck in heavy traffic congestion (Table 8, quote *xii*).

These results highlight a number of problems that exist in activating the application. While automatic activation appears to be the primary determinant of success of the activation, participants would still report deactivating the application if they either felt it was unnecessary or if the application conflicted with desired phone functions. As such, this result illustrates that it is not only important for these types of applications to improve the ease with which they can be activated, but they also need to focus on improving their usability. The following theme further explores the usability of the application while it is activated.

4.2.3. Theme: usability

Usability, or perceptions of the ability to use the application for its intended purpose, was mixed. Similarly to activation, usability is necessary to consider when evaluating the application, as those who find a number of problems with the usability of the application are unlikely to continue using it. Importantly, if there are problems with usability, this may also mean that the application is not as effective as it can be in preventing mobile phone distracted driving; in fact, it may even cause more distraction.

A successful experience with the usability of the application was largely connected to the blocking of text messages (Table 9, quote *i*). Participants reported being less distracted by their phone when driving due to this, as they were not made aware of a reason to check their phone (Table 9, quote *ii*). The applications also gave the option of sending a message to the person who sent a text to the driver while the application was activated, notifying them that the driver cannot be reached at that time. This function was viewed positively by participants when it was working properly; however, there were some instances in which this function was reported not to work (Table 9, quote *iii*) or continued working even when the participant was not driving (Table 9, quote *iv*).

Participants associated successful usability with call, navigation and music functions 1) being allowed and 2) working properly (Table 9, quote *v*). These functions were reportedly the most common reasons for using the phone while driving, as when they worked properly, participants perceived the usability of the application to be successful. As such, when this is combined with the lack of notifications from text messages and the blank screen when no phone functions were being used, strong positive perceptions of the application were reported. Meanwhile, a number of problems with the usability of the application were also reported. As previously mentioned, there were some positive experiences associated with the use of music while driving, while others reported major problems associated with this. There were problems reported with skipping songs on the application (Table 9, quote *vi*) as well as compatibility problems reported specifically with the popular music streaming application 'Spotify' (Table 9, quote *vii*).

Problems with the voice functions of the applications were also reported. Controlling certain functions of the application via voice control was found to not work at times. This was associated with iOS phone users, in which the 'Siri' voice control had limited functionality with the application (Table 9, quote *viii*). Some instances of inaccuracies in the text to voice function was also reported, in which the application was unable to accurately read out certain messages (Table 9, quote *ix*).

There were also language problems associated with the application. The language appeared to be set to English, therefore there were some difficulties for those who had a first language other than English. Commanding Siri in iOS phones was reportedly problematic due to either an accent or for participants who were not fluent in English (Table 9, quote *x*). Further, a participant noted they use a language other than English to communicate in text, so when asked to read a text message aloud, the application read it out as if it was in English, creating confusion (Table 9, quote *xi*).

A major concern among participants with the application was associated with battery use. The applications reportedly used up a lot of phone battery power when in use (Table 9, quote *xii*). Battery drainage can be a large deterrent for some drivers, acting as a disincentive from further using the application, especially if a person's phone battery power is already low. It was reported that people could also become distracted while driving if they notice their battery is being drained (Table 9, quote *xiii*).

While the application was reported to successfully block text messages in a number of instances, there were problems with other applications giving notifications that do not get blocked. In particular, the messaging applications of Facebook Messenger and WhatsApp were reported to continue to come through in some cases (Table 9, quotes *xiv-xv*). It was noted that communication applications outside of the basic phone functions (i.e. call and text functions) are preferred among some people, especially when communicating internationally. As such, it was stated that these types of applications need to be better integrated for usability with the application (Table 9, quote xvi). This highlights the need to further develop these types of applications designed to prevent distracting phone use while driving to incorporate a number of additional applications. As the application market is constantly evolving, this would also need to be regularly updated to ensure compatibility with emerging popular applications.

Participants also gave examples of specific problems they experienced with the application that influenced them to ultimately stop activating it. One such problem included the perception that exemptions defeat the purpose of the application. This is an interesting result as the exemption feature was identified as a contributing factor to using the application for some participants, while others decided not to use the

Table 9
Selected quotes relevant to usability.

	Relevant Quotes
i	Only received two texts while driving, both times the auto reply went out. So no problems with the app. (F, 28)
ii	Because I do not get notifications on my phone I feel that I am more focused. (F, 29)
iii	It was not sending my 'I am driving' text when receiving messages… Googled it and apparently it is a common problem. It was too annoying to keep trying so I gave up and just used it the app via my phone. (F, 43)
iv	The app activated when I'm a passenger which can be annoying to have to turn it off constantly. (F, 35)
v	I use it to navigate to unknown areas. It does a good job. Shows GPS and allows music selections and manage calls. (M, 39)
vi	I cannot switch between songs with the app on my car's wheel skip button. I need this when I'm driving so I don't freak out. (F, 27)
vii	When I want to turn Spotify on, I need to unlock the phone and it stops the 'Do Not Disturb' app as only 2 options offered are "cancel" or "I'm not driving (F, 33)
viii	I appreciate not having the distractions of my phone vibrating while driving but it can add an extra hurdle because some of Siri's functionality is turned off (M, 32)
ix	The message reading thing is still not great. It talks too fast and sometimes when can be bit confusing. For example, "damnnnn dudee" became a game of spelling and guessing. It spelled out the letters. Voice to text is generally pretty good though. (M, 21)
x	I am using Asus Zenphone with a large battery capacity, however, when I used this app after a while, the phone give me a warning that this app is draining the battery more than other apps. (M, 35)
xi	One problem that I had is that for long trips, the battery was running low and I had to plug in the phone. Maybe it would be useful to get a message when activating the app saying 'remember to charge your phone.' A lot of people will be distracted if they notice that their phone is running out of battery. (M, 29)
xii	I believe the verbal contact with Siri must be improved a lot more, especially for non-native English speakers. For them, it is too difficult to command Siri to do stuff and as a result you would see Siri is mostly used only by native English speakers. (M, 43)
xiii	Since I also use another language (Indonesian) to communicate, the app read the Indonesian text/message in English style that makes it really annoying during my driving. (M, 35)
xiv	It was a good feeling because I could switch my mind to not look for receiving any calls. However when my phone rang from WhatsApp, it kind of ruined my feeling. (M, 43)
xv	It helps me with the map and manages my messages easily, it makes my phone view get more simple and easy to manage. However, since there is no option to set up what social media messages that I would like to monitor, the app gives me all notification, which was very annoying for me. (M, 35)
xvi	This time I had a kind of new experience. While the app was activated I received an international calls from WhatsApp. I realized that 'Do Not Disturb While Driving' (DDWD) does not block calls from the apps with voice communication ability. In addition to WhatsApp, I am using some of them such as Telegram, Voxaphone, Viber and Imo among others. (M, 43)
xvii	I stopped using the app. I was a lot more aware of my mobile phone usage as I was part of the study, but I ended up making exceptions to my family calling, which defeated the purpose (F, 26)
xviii	I keep meaning to make an exception to the app for my elderly mother who has one of those emergency buzzers in case she trips and falls. However, because her number is listed as a private number I'm not sure how to make that exception. This is a bit troubling as I wouldn't want to miss an emergency call from her. (F, 47)
xix	I stopped activating the app. It is way too easy to turn off as all you have to do is click the button from the home screen, and it does this in my pocket. (F, 26)

application because of this feature. For example, one participant stated they use exemptions to allow calls from their family to come through. They decided this exemption outweighed any benefits from using the application and consequently stopped activating the application (Table 9, quote *xvii*). Another problem associated with the exemption feature was the difficulty in allowing private calls. A participant reported they wanted to allow their mother's calls to come through their phone in case of emergencies, but the mother had a private number, therefore the participant was not able to set their mother as an exemption (Table 9, quote *xviii*). It was also reported that it can be too easy to turn off the application, for example, if a participant placed their phone in their pocket while driving, they could accidentally press the 'home' button on their phone which can disable the application (Table 9, quote *xix*). While this was an unintentional reason for deactivating the application, it also acted as a reason for participants to decide to stop activating the application in their future drives.

These results show that usability is mixed for the applications designed to prevent mobile phone distracted driving. Even if there are no problems experienced with the application, there can be a learning curve when first starting to use it. However, as there are many usability issues, it is likely they need to be fixed before these types of applications will be adopted more widely.

4.2.4. Theme: behavioural adaptations to the application

There were some difficulties with using the application associated with participants' need to spend time to familiarise themselves with it. It was stated that initially, the application was not always intuitive, however, after adapting to the application, participants reported much more positive experiences with it (Table 10, quote *i*). Encouragingly, after having more experience with the application, participants also reported no longer feeling as tempted to use their phone while driving (Table 10, quotes *ii-iii*). Reported visual-manual interactions with phone use while driving in particular decreased after using the application. This included no longer touching the phone to check for notifications, opening up and reading text messages, changing songs on the phone and making calls. The voice activation feature in particular aided participants to change from visual-manual to cognitive-auditory functions for reading text messages and making phone calls (Table 10, quote *iv*). In some cases, using the application generally increased participants' awareness of their normal distracted driving behaviours and as a result, they engaged in more adaptive behaviours to decrease their risk, such as pulling over to make a call instead of doing it while driving (Table 10, quote *v*). After using the application for a while, some participants reported completely forgetting about their phone while driving (Table 10, quote *vi*). However, if participants mentioned being habituated to using their phone while driving, it was reported that it took longer to get used to no longer trying to check notifications (Table 10, quote *vii*). It is also important to note that these positive experiences are reported among participants with whom the application was working well.

Participants who had overall negative experiences with the application, particularly with usability of the application, demonstrated a downgrading of their opinion of the application so that by the third diary entry, their views of the application were very low, with no intention to continue using the application after the study had finished (Table 10, quote *viii*). The problems were largely related to the visual set-up of the application, including not being familiar with the set-up, difficulty switching between songs and checking the time on the phone, perceptions that there is more distraction associated with using the application (particularly mentioned when the participant was not familiar with the location of specific functions of the application) and a lack of synchronisation between the application and the car. Interestingly, the participants who reported these negative perceptions of the application over time also reported that they frequently engage in both visual-manual and cognitive-auditory phone use while driving behaviours.

These findings demonstrate that while perceptions of usability increased after using the application for a period of time, this is only

Table 10
Selected quotes relevant to behavioural adaptation to the application.

	Relevant Quotes
i	Remembering to activate the app before I start driving. I struggled to learn how to make exceptions but now it is fine (F, 26)
ii	Very good! I feel much more relaxed about it than when I started this study and I think I'm less aware of the app and less aware of my phone. I went for a longer than usual drive today which is when I usually get a bit bored and check for texts/fb messages, but I didn't really feel the need to do it this time. I actually like the fact that when I'm stopped and safe I can read through all the messages that have come through. I feel like a better/more responsible driver. (F, 35)
iii	Given that the notifications from most apps are hidden, I had a quick look at the phone out of habit but did not proceed to use it while driving or stopped at an intersection. With continued use, I could see myself ignoring the phone on most/all journeys all together. (M, 30)
iv	When a text message come through the app automatically reads it out and then google assistant proceeds to ask if I would like to reply. Generally I just say no as the message is not important, however, I would most likely reply to the message if it was important enough. Replying would be no different than just having a conversation with someone inside the car. (M, 19)
v	Yes, it especially made me more conscious in driving. For example, I wanted to make a very important short call the other day and because of the app I pulled the car over on the side of the road, made the call and after finished it I kept going. That was a new reaction from me, I believe. (M, 43)
vi	There is no experience to describe, because nothing happens! I actually forget, and then I might notice a message once I am back at home, or at my destination (F, 42)
vii	Still tapped screen a couple of times at traffic lights to see if there are any messages and to check time etc, but no messages obviously. Would probably take a longer period for me to change the habit of tapping screen when at a red light. (F, 22)
viii	I loathe the app now, I only turn it on when I think about the study and then turn it immediately off. (F, 27)

applicable when the application worked properly. When the application was working as it was supposed to, participants reported that phone use while driving decreased, including temptations to use the phone while driving. Some participants even switched from visual-manual phone use to cognitive-auditory phone use.

5. Discussion and conclusion

This study used a mixed methods design to explore the use of voluntary applications designed to prevent distracted driving. The quantitative study assessed the impact the application had on reducing different types of distracted driving behaviours, while the qualitative component allowed a deeper exploration of drivers' use of the application, and provided an understanding of their perceptions towards it. The results are discussed according to each research question.

Research question 1, ‘Does using the application reduce driver's engagement with mobile phone distracted driving?’ was addressed primarily via the quantitative results, with the qualitative results providing more context to answer this question further. Engagement in mobile phone use while driving significantly decreased after using the application for 1) visual-manual phone tasks, 2) cognitive auditory phone tasks and 3) music-related tasks. The visual-manual result is consistent with the results from a previous study by Albert and Lotan (2019) that found the engagement with an application designed to prevent distracted driving reduced phone touches by 20 %. Meanwhile, engagement in social media and games while driving did not significantly decrease after using the application. This may be due to reported engagement in this behaviour being low to begin with. It was also found that reported distraction engagement (from the SDDQ) and mental demand while driving (from the NASA TLX) significantly decreased after participants used the application. Overall, these results suggest that the applications were effective in reducing exposure to mobile phone distracted driving.

Although distraction engagement has been found to significantly decrease while using the application, reported susceptibility to involuntary distraction did not change. It is important to note the involuntary distraction subscale from the SDDQ relates to a driver's capacity to supress involuntary distractions (Feng et al., 2014). An example of a susceptibility to involuntary distraction questionnaire item is as follows: “While driving, you find it distracting when your phone is ringing”. In comparison, the distraction engagement subscale asked about their experience with the behaviour, for example “when driving, you hold phone conversations”. As such, these findings reflect that the application did not modify driver's capability to supress distractions. However, the qualitative results found support for a reduction in exposure to involuntary distraction when using the application (i.e., notifications or incoming calls). Using an application designed to permit music and GPS functions while blocking notifications and other types of apps such as social media and texting would reduce exposure to unexpected phone interruptions (Oviedo-Trespalacios et al., 2019d). This has implications for road safety given that previous research has found that incoming notifications are associated with reduced situation awareness (Van Dam et al., 2019). Participants reported positive experiences with the application when it blocked notifications popping up on the phone, for example, when they were using a navigation application. Nevertheless, other participants reported application malfunctions, where notifications were not blocked when they were supposed to be. Additionally, it was noted that the application did not block messages from certain applications, such as the instant message applications of Facebook Messenger and WhatsApp. This could be very dangerous and further developments are needed to prevent these interruptions while driving.

The other SDDQ subscales of attitude, social norms and control also did not change during the study. While the diary entries revealed changes in attitudes towards the application, there was limited mention of changes in attitude towards distracted driving, other than becoming more aware of their own experiences with distracted driving. Participants also did not mention any social norms towards distracted driving. Perceived control measured drivers' perceptions of how much distraction can impact their driving; this construct also did not have a focus within the diary entries. Similarly, the constructs behind the NASA TLX items that did not significantly change over time (physical demand, temporal demand, performance, effort and frustration) were not discussed within the diary entries, suggesting they were not impacted by the use of the application.

While both visual-manual and cognitive-auditory interactions with a mobile phone while driving significantly reduced when the application was active, these behaviours were still reported to occur during the study. On occasion, visual-manual phone interactions occurred because of malfunctions with the application. The diary entries revealed the types of visual-manual interactions participants engaged in, including exiting the application if it was malfunctioning, switching between features of the application, answering phone calls, interacting with a navigation or music application, browsing the internet and turning off the phone screen to save battery. The quantitative results found that visual-manual phone use was highly correlated with the use of music while driving, suggesting a large component of participants' visual-manual phone use involved the interaction with music applications. To the best of the authors' knowledge, this is the first study to illuminate the phone behaviours that occur while using an application designed to prevent distracted driving, resulting in a lack of comparison with the literature for this finding. However, other qualitative research that has examined drivers' engagement in phone use while driving generally has also found that drivers frequently engage in navigation and music applications (George et al., 2018; Truelove et al., 2018) as well as answering calls and browsing the internet (George et al., 2018).

Cognitive-auditory functions consisted of listening to music or podcasts, using Bluetooth and verbally requesting phone functions. In some cases, participants reported adapting their behaviour to utilise cognitive-auditory phone functions while driving instead of visual-manual phone functions. For example, some participants would set up the functions of the application before they started driving so they either did not need to interact with the phone once they began their drive or else could rely upon voice commands. It is important to highlight that the change from visual-manual to voice-auditory interactions has important safety benefits as highlighted in previous research (Oviedo-Trespalacios et al., 2016; Simmons et al., 2016). In contrast, when participants were using visual-manual phone interactions, they engaged in adaptive behaviours by primarily using these functions either at traffic lights or in slow moving traffic. This is consistent with previous research that has found drivers frequently engage in self-regulating behaviour when using a phone while driving (Oviedo-Trespalacios et al., 2019e; Oviedo-Trespalacios, 2018). While Oviedo-Trespalacios et al. (2018) also found that drivers regulate their phone use while driving behaviour via the location (e.g. at traffic lights), this study extends upon this research by identifying that the use of applications designed to prevent distracted driving can also support self-regulation of mobile phone interactions.

The qualitative component of this study answered research question 2: "What are drivers' experiences with the application?" Drivers' reported some difficulties with the application to begin with, including difficulties learning how to operate it, as well as not being used to the lack of control. However, after becoming more familiar with the application, perceptions became more positive towards it. Previous studies have found limited acceptance of applications that block phone functions while driving (McGinn, 2014; Ponte et al., 2016), as such, it is possible that taking time to experience the application and learn about its functions may result in more acceptance of the application and subsequently, more engagement with it. However, the feasibility of implementing this in a real world scenario is difficult; drivers may give up on the application after initial difficulties when they do not have any external motivators to convince them to continue activating it. It has been suggested that incentives are a possible measure for promoting the use of these applications (Oviedo-Trespalacios et al., 2019d).

Finally, research question 3 "What functions of the application need to be improved?" was also answered via the diary entries. Activation issues were a popular theme discussed among participants. Firstly, it was reportedly difficult to remember to activate it before starting the drive, as this behaviour was new to participants. Additionally, some participants found the manual activation confusing, which acted as a barrier to utilising it. In comparison, drivers who were able to use automatic activation had better experiences with the application. However, the type of activation was not dependent on the participant's phone; instead it was dependent on their vehicle. Vehicles with good Bluetooth connectivity allowed the automatic activation of the application; this is an important consideration for the effectiveness of applications designed to prevent distracted driving. The success of these applications is highly dependent on the vehicle technology.

As discussed within the themes, other key areas of improvement included 1) better integration with other phone functions, 2) less battery drainage, 3) the ability to integrate languages other than English, 4) the ability to block pop-up messages outside of texts, for example, Facebook Messenger and WhatsApp messages, 5) making the application more intuitive, 6) improving the visual-set-up and 7) ensuring the application does not malfunction. Participants reported many problems with the application malfunctioning. Specific malfunctions included problems with the voice function, lack of synchronisation with their vehicle, and problems with the automatic message feature. Those who experienced many difficulties with the application and decided to discontinue activating also reported high levels of engagement in mobile phone distracted driving. These drivers are a target market for the application. Consequently, these results highlight the importance of improving applications to increase their engagement among target populations. Meanwhile, the exemption feature of the application had mixed perceptions. This feature allows specific contacts or specific phone functions to work while the application is activated. Consistent with previous research (Park et al., 2018), some drivers reported favourable attitudes towards the exemption feature. Meanwhile, others believed this defeated the purpose of the application, as drivers could still be distracted by phone features they exempted. A balance between exemptions that would encourage drivers to utilise the application, while ensuring phone features that have proven to be dangerous are not included in exemptions, is a possible solution. It is crucial that the usability of the application is improved to allow more drivers to engage with the application.

Privacy was also a reported concern among participants. The applications require access to a number of phone features, for example, messages and calls, to allow these functions to be blocked while driving. This was reported to be a concern among a small number of participants. It is suggested that the application would benefit from a statement describing the confidentiality of the accessible information.

To our knowledge, this study is the first mixed methods design to analyse how phone applications currently on the market impact drivers. The inclusion of the survey allowed quantifiable results while the diary entries provided an in-depth understanding of drivers' experiences and perceptions of the application. However, it is important to acknowledge the limitations. The sample included 40 participants; while this is a large amount of data for the qualitative analyses, future research should aim to have a larger sample size when conducting quantitative analyses. Further, the generalisability of the sample needs to be considered. Drivers were recruited within Australia, so it is possible the results would differ among a population outside of Australia. Additionally, the participants' ages ranged between 18 and 56 years. While this provides a good representation of different age groups, it is possible perceptions of the application would diverge between age groups. Future research could examine differences between younger and older samples.

This study provides an important addition to the extant literature on applications designed to prevent mobile phone distracted driving. These applications have been shown to decrease phone use while driving, as well as mental workload. However, a number of areas of improvement have been identified that need to be addressed to allow more drivers to firstly engage with the application and subsequently continue to use it when driving.

Funding

Dr Oscar Oviedo-Trespalacios is the recipient of an Australian Research Council Discovery Early Career Researcher Award [DE200101079] funded by the Australian Government. This study was partially supported by a research grant from the Royal Automobile Club of Victoria (RACV) 2017-2018. The contents of this study are the sole responsability of the authors and do not necessarily represent the official views of the Royal Automobile Club of Victoria.

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