A Diary Study of Distracted Driving Behaviours

# Abstract

The introduction and uptake of technology within road vehicles has readily advanced their capabilities and the functions that drivers’ of the vehicle have available to them. While this has benefited the drivers’ productivity and entertainment behind the wheel, it has also heightened the possibility for distraction. Research into driver distraction to date has identified how technologies inside the vehicle may be used ineffectively and can compromise the safety of the road transport system. Yet, the factors that drivers state impact on their decision to engage with distracting technologies are less well known. This paper presents the first diary study into driver distraction. It asked drivers to record all technological distractions that they engaged with across a 4-week period, as well as interactions that they ignored or choose not to engage with. The diary entries include the technologies drivers interacted with and the conditions surrounding this, as well as external factors that drivers cited to influence their decision to interact. Primarily, factors relating to the task itself were found to be of most importance to the drivers’ decision to engage. Differences were also found in how drivers stated they compensated for any engagement with distracting tasks. This has important consequences for the design and integration of technological devices into the vehicle. The novel application of the method offers insights into the naturalistic conditions surrounding drivers’ involvement with distracting technologies. The method is reviewed on its applicability to the study of driver distraction.

# Introduction

Distractions are tasks that drivers engage with while driving that prevent them from maintaining safe control of the vehicle (Lee et al, 2008; Pettit et al, 2005; Hedlund et al, 2005; Ranney et al, 2000). The placement of tasks inside the vehicle that do not assist the driver, or take their attention away from, their safe management of the driving task are therefore a cause for concern. The automotive domain has been increasingly depended upon in society as a key mode of transport (McCarthy, 2007; Cohen, 2012) leading to drivers spending more time in their vehicle (INRIX, 2017). The vehicle has therefore become increasingly flooded with additional technologies to engage the drivers’ attention. While some of these technologies assist the driving task, they also provide additional tasks that may conflict with safe management of the vehicle such as communication, navigation and entertainment tasks (Harvey et al, 2011a). Human Factors research is required to understand the demands of these devices, how they are used and facilitate their safe use in the vehicle, where this is viable.

To determine the possibility for distraction from devices in the vehicle, research must identify the sources of attention that may overload the driver. Driving simulators have been used to assess distraction from mobile phones (Horrey et al, 2006; Papadakaki et al, 2016), navigation devices (Tsimhoni et al, 2004; Harvey & Stanton, 2013), hands-free technology (Treffner & Barrett, 2004; Yan et al, 2018) as well as the interface design of in-vehicle systems (Harvey et al, 2011b; Birrell & Young, 2011). This has helped to determine the risks that devices such as hand-held mobile phones pose to road safety (Horrey et al, 2006; Caird et al, 2014; Lipovac et al, 2017), leading to their ban behind the wheel. The development of standards and guidelines (e.g. Visual-manual NHTSA driver distraction guidelines for in-vehicle electronic devices; NHTSA 2013) for the production of safe and effective interfaces within the vehicle have also highlighted the importance of simulation research in testing devices before they are put in to use on the roads. There are, however, some shortcomings to the use of driving simulators as they do not fully capture the risks and environmental factors that are found in the real world. Furthermore, the focus within simulator studies is invariably on the drivers’ behaviour, their performance and behavioural metrics that are interpreted to determine the impact that distracting tasks may have on road safety. Other factors that may surround the uptake of technologies, driver preference and contextual factors are little considered (Parnell et al, 2018c). Furthermore, simulator studies do not consider the motivation, desire or varying contexts of use that can influence the safe maintenance of the driving tasks while engaging with the device (Carsten et al, 2013). Furthermore, there are often workarounds that occur within the normal everyday functioning of systems that individuals perform to prevent failure and these can only be captured when assessing naturally occurring behaviour and ethnographic research (Baxter & Sommerville, 2011).

Large scale and longitudinal naturalistic driving studies have highlighted the prevalence of driver distraction. The Strategic Highway Research Program (SHRP 2), ran from 2006-2015 and comprised of 3,524 participating drivers in the USA. Participants vehicles were fitted with data acquisition systems that could capture their driving performance as well as recordings of their driving behaviour. Dingus et al (2016) reviewed the data from this study and found that distraction was evident in 51.98% of normal driving states and 68.3% of the injury/property damage crashes that occurred within the study. Furthermore, it was found that distracted driving results in a crash risk that is 2 times higher than full attentive driving (Dingus et al, 2016). In Europe, the first large-scale naturalistic driving study was UDrive, which included 287 drivers (cars, trucks and powered two-wheel vehicles) from five different European countries and collected data over a period of 12-18months. This identified behavioural differences between drivers from different countries within Europe as well as key differences between European drivers and USA drivers (van Nes, 2019). With regard to distraction, it was found that European drivers were distracted 10% of their driving time (Carsten et al, 2017), less than that reported from the SHRP 2 study in the USA. Yet, this too varied across European countries (Carsten et al, 2017). The Australian Naturalistic Driving Study (ANDS) identified that a sample of 379 Australian drivers engaged in one or more secondary task every 96seconds on average, while driving (Young et al, 2019). Yet, naturalistic studies have also shown some evidence for compensatory strategies and modified behaviours to reduce the risk of engaging with secondary tasks. The ANDS found that drivers are more likely to engage with secondary tasks when the vehicle was stationary and interactions while driving were for shorter time periods (Young et al, 2019). The UDrive study found similar findings, with drivers more likely to interact with tasks while stationary and interactions occurring at slower speeds, with drivers slowing down to interact in visual-manual tasks (Carsten et al, 2017). This suggests drivers employ, to some extent, a strategic approach to their engagement with secondary tasks while driving. The large-scale naturalistic studies have been able to present evidence for the prevalence of distracted driving behaviours and the contexts within which it occurs.

While there has been much research into the cause and effect relationship between distractions and driver behaviour, an understanding of why drivers choose to engage with distractions has been of a lesser focus (Young & Salmon, 2012; Parnell et al, 2018a). To reduce the issue of driver distraction and improve road safety, it is important to fully understand all factors that may motivate the use of distracting devices. This includes how they are used by the driver and where there may be opportunity to prevent distracting behaviour from compromising the safe management of the driving task. Young and Salmon (2015) first identified that to fully understand the scale and implications of the behaviour, a systems view needed to be taken to capture all actors that influence the potential for distraction in the road traffic system. Parnell et al (2018d) further identified the utility in taking this approach to the study of technological distractions, whose development is a product of both societal and technological development. They define distraction as “*the diversion of attention from the main goal of arriving at the destination safely, caused by broader systemic factors at all levels (such as government policy, HMI manufacturers, media, road infrastructure, weather, traffic etc.) acting upon driver priorities, demands, resources, conflicts and constraints (identified in the PARRC model)*” (p185, Parnell et al, 2018d), thus, highlighting the role of the system in diverting attention away from safe behaviours. By utilising methods that obtain data on the drivers own motivations and decision-making process to engage with distracting technologies, the role of manufacturers, environmental conditions and legislation have begun to be exposed (Parnell et al, 2017; Parnell et al, 2018a).

The large-scale naturalistic studies into driver distraction have been very beneficial in capturing the wider setting within which distractions are engaged and used, as well as how they impact on driver distraction. An alternative and less explored method to capture naturalistic driving behaviour is, however, presented in this paper. Self-report methods are beneficial for their ability to capture of the drivers views on their interactions with distractions, the workarounds that they may have to apply to conduct their day to day activities while driving and the reasoning for their own behaviour. This facilitates an understanding of why distractions may occur (Parnell et al, 2018a). Online surveys have been a popular self-report method that have sought to obtain the frequency with which drivers engage with technology, as well as how they perceive the risks of certain behaviours (White et al, 2004, Young & Lenné, 2010). Interviews with drivers have also facilitated a more open-ended discussion surrounding the interactions that drivers make with technologies while driving (Parnell et al, 2018a). Yet, self-report based research methods are open to researcher effects and social desirability bias, especially when the research involves participants declaring behaviour that is illegal, such as mobile phone use while driving. The use of online survey methods has strived to overcome this by asking drivers to anonymously give information on the distractions that they engage with (White et al, 2004; Young & Lenné, 2010). Yet, the level of detail that can be gained from this method is somewhat limited.

A method that has not yet been considered in the field of driver distraction is diary studies. Diary studies ask participants to keep a record of their behaviour over a period of time in order to capture their naturalistic behaviours across this period. Anonymity of the diary entries strives to minimise social desirability issues, while the ability to capture longitudinal data can obtain insights into the behaviour that cannot be captured in laboratories as these can only capture a snapshot in time. Thus, diary studies lend themselves to a richer data set than online surveys can provide, while still facilitating anonymity and the absence of any direct researcher observation effect. Diary studies cannot, however, capture the scale of interactions that large-scale naturalistic observation studies such as UDrive, SHRP2 and ANDS can, yet they do capture the drivers view point. This can allow for the factors surrounding behaviour to be explored, including the drivers’ thoughts on their behaviour and their self-justification for their actions.

Diary studies have been used elsewhere in the driving domain to assess driving stress, with their ability to capture the temporal and interactional nature of the drivers’ stress levels, including personal events, to build a bigger picture of the issue (Gulian et al, 1990). They have also been used to measure individuals everyday travel behaviours (Axhausen et al, 2012), as well as risk perceptions of different road users and their exposure to incidents or near misses on the road (Joshi et al, 2001). The complexity and interactional nature of distraction (Young & Salmon, 2015; Parnell et al, 2018c; Parnell et al, 2018d) suggests there is much opportunity for diary studies to offer an understanding of how drivers come to engage with distractions and the wider context that may influence this. As this is a self-report study there is still opportunity for reporting bias, however it is of interest to determine the applicability of his novel method to the study of driver distraction.

This study therefore aims to identify the factors that contribute to drivers becoming distracted by technology in the vehicle with a diary study. This will capture the drivers self-reported behaviour and their reasoning behind it, in order to obtain an understanding of their decision-making processes. Technological tasks that were interacted with as well as those that were purposefully ignored were sought to capture all possible interactions. The environmental factors surrounding interactions with technological task, as well as details about the task itself, were captured. This aims to develop understanding on why drivers engage with distracting technology and the contextual factors surrounding it.

# Method

## Participants

Nineteen participants were initially recruited to take part in the study, 15 (8 males, 7 females) of these went on to complete the required diary entries for the data analysis, with the remaining lost through attrition. Participants had to be at least 18 years of age, with a full UK driving license to take part, in line with the ethical committee requirements. Participants ranged in age between 18-57 years (Mean=31.2years, Range=38.5years, SD=10.8years). They also had to be regular drivers of their own vehicles to capture the data required. Participation was voluntary, but if participants completed the required number of questionnaires they were entered into a prize draw. This incentivised their completion of the required number of questionnaires for the data analysis.

Participation in the study was anonymous and confidential to encourage truthful data to be collected without repercussions. Ethical approval was granted by the University Ethics Committee (Ergo ID: 25177).

## Experimental design

It was important that the diary questionnaire collected detailed information surrounding the drivers’ behaviour and the journey, while also being quick and convenient to encourage them to complete it on a regular basis. Therefore, tick box and closed questions were predominantly used to effectively collect data on the required parameters for comparable results across participants. Yet, to capture more details surrounding the behaviours, drivers were also encouraged to complete an open-ended questionnaire to explain their actions and decision-making processes during the journey.

For each journey/interaction the questionnaire required the participants to fill in information relating to the following key areas:

*Technology interaction behaviour:* There was an option to select if technological interaction had occurred or not. There was also an option to note if there was an interaction from the device was made (e.g. an alert) but no attempt to interact from the driver was made and the interaction was ignored. If they selected that they did interact with technology while driving, participants were required to select which technology they interacted with. They could select from the following technologies: Sat-nav, infotainment system, hand-held phone, hands-free phone. They also had to state if these were devices built into the vehicle or if they were personal/portable devices. They also had an ‘other’ option if their interaction was not included in the original list on the questionnaire. They were then asked to state if the interaction was driver initiated i.e. the driver prompted the interaction themselves, or device initiated i.e. an alert or message initiated by the device itself. If they did interact with the technology they were asked if they compensated their behaviour in any way to manage the interaction. This is in line with common findings in the literature that participants often compensate for the increased demand of interacting with distracting secondary tasks while driving (Alm & Nilsson, 1995; Strayer et al, 2003).

*Interaction Activity:* The interaction was also classified on the actions that were involved. Participants were asked to tick which of the following activities were involved in the interactions they made; Reading, writing, listening, speaking, interacting, monitoring. They were given training on how these were defined as well as examples. Reading was deemed to involve reviewing and processing written content e.g. a message, writing involved producing text e.g. texting, listening required audio processing either in a phone call or from a voice system, speaking relating to verbal commands or phone calls, interacting was the physical touch and interaction with a device and monitoring involved the glances to a device to gain updates or feedback e.g. navigation information.

*Journey Characteristics:* The characteristics of the journey were asked for to assess its purpose and familiarity to the participant. They were asked to select if the drive was a commute, for leisure, business or ‘other’. The point in the journey was also captured with participants noting the time remaining within the journey that the interaction occurred.

*Environmental conditions:* The driving conditions at the point of the interaction (or the ignored interaction) were required to assess how factors such as the speed limit (mph), road type (Motorway, major A/B road, rural, urban, residential or junction), traffic levels (stationary, slow moving, normal speeds) or weather conditions (light/dark, wet/dry, sunny/cloudy, fog, ice) related to the decision to engage, or not.

*Passengers present:* The presence of passengers, or lack thereof, was captured to see if this had any effect on the participants behaviour and interactions. The number of passengers present in the vehicle at the time of the interaction was also collected.

*Time of travel:* The time of travel was also captured so that peak and off-peak journeys could be compared. Participants wrote down the time of the interaction and these were then classified as peak or off-peak in the analysis. Peak hours were considered to be between 6.30am-10am and 4.30pm-7pm on weekdays. All other times were off-peak.

*Self-justification:* While the above factors were captured through closed questions, an open-ended question asked the participant to state the conditions surrounding their interaction behaviour, suggesting why they engaged or chose to ignore the technology. This hoped to capture the participants beliefs and attitudes surrounding their behaviours.

During a two-week pilot study with three participants, the appropriateness of the questionnaires was determined with amendments to the phrasing of the questions and the possible tick box answers. It was also identified that multiple interactions may occur per journey and therefore a separate questionnaire should to be completed per interaction, rather than per journey.

## Equipment

The questionnaires were paper based and given to participants in a booklet that would act as a visual reminder to complete them at the end of each drive. They had a bright yellow sign on the clipboard reminding the participant to complete after every drive. Participants were encouraged to leave the questionnaire booklet in their vehicles as a reminder. Paper based questionnaires also allowed those who may be less confident in using technology to take part in the study.

Participants were required to own and drive their own vehicle when taking part in the study. This would ensure that the naturalistic behaviour captured aligned with their normal behaviour in everyday life, as well as their access to the technological devices that they may use while driving.

## Procedure

Upon being recruited, participants initially attended a joint informative session that would detail what would be required of them. They also completed the demographics questions at the training session before they were given a booklet of empty questionnaire to take away and complete on their car journeys. Participants were also free to ask the researchers any questions they may have at this session and given contact details for any future questions.

Participants were required to complete a questionnaire detailing their interactions with technological distraction for each drive that they completed over a 4-week period, spanning March to September. They were told to complete the questionnaire only at the end of the journey, once the car was safely parked and the engine switched off. They were encouraged to complete the questionnaires while still sat in the car (parked and engine off) to prime their responses and encourage them to complete it as soon after the behaviours had occurred as possible. They were also encouraged to complete the questionnaires as honestly as possible, with no repercussions to their entries which may suggest distractive or illegal behaviours. This hoped to enable true self-report data. The participants were told to keep the questionnaire booklet in their cars at all times. At the end of the 4-week period and when the minimum of 20 questionnaires had been completed the participants were required to return their booklets to the researcher.

## Data analysis

As drivers were asked to fill in the diary questionnaires when an interaction occurred or was ignored, interactions that were driver initiated or device initiated were analysed and compared to cases where the interactions were ignored. This data collection method meant, however, that cases where no interaction occurred at all could not be included in the analysis. The factors that influenced the drivers’ interactions with the technologies that were included in the analysis included the number of passengers, speed limit, road type, traffic conditions, weather conditions, trip purpose and time left on the journey. The type of interactions that occurred were also of interest as well as the technology device used and any compensation strategy that they used when engaging.

# Results

## Overview of technology interaction

374 questionnaires were completed by the participants, with an average of 24.93 completed per participant (SD=6.4). Figure 1 shows the breakdown of interaction types. There were 211 (56%) interactions with technology, 178 (84%) of these interactions were initiated by the participant (driver), while the other 33 interactions (16%) were device initiated. Of the journeys when interactions did not occur, 119 (73%) reported there was no need to interact with technologies. Yet, the other 44 (27%) journeys without interactions were due to the participant deliberately ignoring the technological that was alerting them to interact with it.

Figure 1. Pie Chart showing the break-down of the frequency of interaction types that were recording through the diary entries.

## Demographics

On average participants spent 9.4 hours a week driving (SD=5.2). There was no correlation between the number of hours spent driving per week and the number of interactions with technology that were captured in the diary study (r=0.337, n=15, p=0.109). Nor did the length of time that participants had held a driving licence for relate to the interactions captured (r=0.04, n=15, p=0.436). Gender effects were assessed but there was no significant effect of gender on the number of interactions made t(13)=1.197, p>0.05, or if these interactions were driver initiated t(13)=0.952, p>0.05 or initiated by the device t(13)=0.941, p>0.05. Females were, however, found to significantly ignore more interactions than males t(13)=0.588, p<0.05, although this effect size is small r=0.16.

## External Factors

Data relating to the journey context was only collected for cases where the participant had stated that there was an interaction with technology that occurred or that was ignored, not if there was no technological interaction at all. Therefore, the types of journeys where technology did not interfere with the driving task could not be determined. Yet, for the interactions that were captured, the aspects of the journey that influenced if the interaction was made, or ignored, could be determined. Table 2 shows the frequency of interactions that were made or ignored for each of the external factors collected. For the interactions that were made, Table 2 also shows the origin of the interaction; driver initiated, or device initiated. The external factors captured are presented across the frequency of these interaction types.

Table 2. Frequency table of the interactions made and their origin, across the external factors assessed.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Interaction** | | **Interaction Origin** | |
| **External Factor** | | **Interact (n)** | **Ignore (n)** | **Driver (n)** | **Device (n)** |
| **Road Type** | | | | | |
|  | Motorway | 45 | 12 | 37 | 8 |
|  | Rural | 19 | 8 | 16 | 3 |
|  | Residential | 27 | 2 | 23 | 4 |
|  | Urban | 63 | 7 | 52 | 11 |
|  | Major | 40 | 11 | 35 | 5 |
|  | Junction | 2 | 0 | 0 | 2 |
|  | Other | 15 | 4 | 15 | 0 |
| **Traffic** | | | | | |
|  | Normal | 139 | 34 | 121 | 18 |
|  | Slower | 47 | 6 | 38 | 9 |
|  | Stationary | 18 | 0 | 13 | 5 |
|  | n/a | 7 | 4 | 6 | 1 |
| **Weather** | | | | | |
|  | Dry/light | 153 | 35 | 129 | 24 |
|  | Wet/light | 23 | 4 | 19 | 4 |
|  | Dry/dark | 17 | 0 | 15 | 2 |
|  | Wet/dark | 6 | 1 | 5 | 1 |
|  | n/a | 12 | 4 | 10 | 2 |
| **Purpose** | | | | | |
|  | Commute | 79 | 20 | 67 | 12 |
|  | Leisure | 98 | 15 | 83 | 15 |
|  | Business | 30 | 5 | 25 | 5 |
|  | n/a | 4 | 4 | 3 | 1 |
| **Passengers** | | | | | |
|  | Passengers | 57 | 13 | 52 | 5 |
|  | No passengers | 154 | 31 | 126 | 28 |
| **Activity** | | | | | |
|  | Physical Interaction | - | - | 58 | 0 |
|  | Read | - | - | 3 | 11 |
|  | Monitor | - | - | 24 | 1 |
|  | Speak | - | - | 5 | 4 |
|  | Listen | - | - | 12 | 1 |
|  | Multiple | - | - | 73 | 16 |
|  | Writing | - | - | 3 | 0 |
| **Journey time remaining** | | | | | |
|  | ≤20 mins | 129 | 30 | 108 | 21 |
|  | >20mins | 60 | 8 | 49 | 11 |
|  | n/a | 22 | 6 | 21 | 1 |
| **Time of Journey** | | | | | |
|  | Peak time | 121 | 32 | 101 | 20 |
|  | Off-peak time | 81 | 12 | 72 | 9 |
|  | N/A | 9 | 0 | 5 | 4 |

Chi squared tests were run to determine if the decision to ignore the technology or interact with it was significantly affected by the external factors. They were also used to determine if the external factors influenced whether the interactions were driver initiated or device initiated. The results from the chi squared tests are shown in Table 3. This shows that none of the external factors significantly effected the proportion of interactions that were made compared to those that were ignored. Furthermore, the external factors did not significantly influence whether the initiations were driver initiated or device initiated. An exception to this was the activity type. The chi squared test showed that there was a significant effect of the type of activity on whether the interaction was initiated by the driver or the device itself (χ2=65.551, df=6, p<0.01). Breaking down this result using standardised residuals to determine how the activity type related to the initiation of the interaction, it was evident that the reading tasks were significantly related by the initiation of the task. More reading interactions than expected were initiated by the device (z=6.0, p<0.01), while less than expected were initiated by the driver (z=-2.6, p<0.01). Furthermore, more speaking tasks than expected were initiated by the device (z=2.2, p<0.05), yet physical interaction tasks occurred less than expected when device initiated.

Table 3. Chi square tests run to determine the effect of external factors on the drivers’ decision to ignore vs interact with the technology and if interactions were driver initiated vs device initiated.

|  |  |  |
| --- | --- | --- |
| **Factor** | **Ignore or Interact (χ2)** | **Driver vs device initiated (χ2)** |
| Road type | χ2=5.139, df=4, p=0.273 | χ2=0.581, df=4, p=0.965 |
| Traffic Conditions | χ2=5.866, df=2, p=0.053 | χ2=3.203, df=2, p=0.202 |
| Weather | χ2=3.996, df=3, p=0.262 | χ2=0.252, df=3, p=0.969 |
| Trip Purpose | χ2=1.975, df=2, p=0.372 | χ2=0.040, df=2, p=0.980 |
| Passengers (0 or some) | χ2=0.596, df=1, p=0.440 | χ2=2.903, df=1, p=0.088 |
| Journey time (<=20mins vs. >20mins) | χ2=1.724, df=1, p=0.189 | χ2=0.123, df=1, p=0.726 |
| Activity | - | χ2=65.551, df=6, p<0.01. |
| Time of journey (peak vs. off-peak) | χ2=2.528, df=1, p=0.112 | χ2=1.128, df=1, p=0.282 |

## Technology types

When interactions occurred (n=211), the majority were with the Infotainment system (51.18%), followed by hands-free phone devices (22.27%), then hand-held phones (17.06%) and a smaller proportion for Satellite Navigation devices (9.00%) and only a single interaction with a smart watch (0.47%) (see Figure 2). The frequency of interactions that were driver initiated versus device initiated are given in Table 4.

Figure 2. Pie chart showing the breakdown of interaction by technological device that was interacted with.

Table 4. Frequency of interactions that driver and device initiated across the difference devices.

|  |  |  |
| --- | --- | --- |
| Device | Initiation (Freq) | |
| Device | Driver |
| Navigation | 4 | 15 |
| Hands-free phone | 13 | 34 |
| Hand-held phone | 15 | 21 |
| Info | 0 | 108 |
| Smart watch | 0 | 1 |

All of the infotainment interactions were driver initiated, none were device initiated. The other device uses were predominantly driver initiated but were also device initiated on occasion. The single smart watch use was driver initiated. A significant effect of initiation type (device or driver) was found on the device that was engaged with (χ2=49.47, df=4, p<0.01). Using the standard residuals to understand this finding it is identified that the influence of the infotainment system being unanimously driver initiated is a significant influencer of this result (z=-4.1, p<0.01). Yet, when the infotainment device was removed no significant effect of initiation type was found on device type (χ2=5.12, df=3, p=0.16).

## Compensatory behaviours

Drivers were asked to note down if they altered their driving behaviour in any way when interacting with the technological device. Drivers reported that in 56 cases they did alter their driving behaviour in some way, but in the remaining 155 interactions no compensatory action related to the driving task was taken. The types of compensatory behaviours that were noted, and their frequency are listed in Table 4. The majority of these involved slowing the vehicle down while interacting with the device (n=27).

Table 4. Frequency of compensation strategies that were noted by participants when they interacted with technologies in the vehicle.

|  |  |
| --- | --- |
| **Compensation Strategy** | **Frequency** |
| Before pulling away | 1 |
| Increase gap | 11 |
| Moved to slow lane | 1 |
| Pulled over | 6 |
| Slowed down | 27 |
| Multiple | 10 |

There was a significant effect of compensation (do compensate versus do not compensate) on interaction initiation type (χ2=9.66, df=1, p<0.05). Drivers were significantly more likely to compensate for their behaviour if the technology is device initiated (z=2.4, p<0.05). Suggesting an increased likelihood of compensation for device-initiated tasks. The standardised residual was not significant for compensatory behaviour that was driver initiated (z=-1.5, p>0.05). When drivers did not compensate their driving behaviour while engaging with the secondary task there was no significant effect of driver initiated (z=0.6, p>0.05) or device-initiated tasks (z=-1.1, p>0.05).

Device type was analysed to see if the device used influenced whether or not the driver compensated their driving behaviour. There was a significant effect of compensation on the device initiated (χ2=40.50, df=4, p<0.01) which suggests that there are some devices that drivers compensate for more. Looking at the standardised residuals shows that drivers compensated significantly less than expected for engagement with the infotainment task (z=-2.9, p<.01). Yet, when interacting with a navigation device or a hand-held phone, participants compensated significantly more than expected (z=2.7, p<0.01 and z=3.7, p<0.01 respectively). Furthermore, drivers reported not to compensate less than was expected when using a hands-free mobile phone (z=-0.4, p<0.05). No other standardised residuals were found to be significant, and thus met expectations.

The frequency counts in Table 5 back these findings up. More interactions with navigation and hand-held phones involved compensation to the driving task than other tasks. While the majority of interactions with the infotainment system were not compensated for in the driving task. This could be attributed to the fact the infotainment systems are designed to limit driver interaction and compensatory behaviour, whereas other devices are not.

Table 5. Frequency of compensatory behaviour and non-compensatory behaviour across devices

|  |  |  |
| --- | --- | --- |
| **Device** | **No compensation** | **Compensation** |
| Infotainment system | 95 | 13 |
| Navigation system | 8 | 11 |
| Hands-free phone | 36 | 11 |
| Handheld phone | 15 | 21 |
| Smart watch | 1 | 0 |

## Self-justification

Participants were given an open-ended question: *“Why did you engage with, or ignore, the technology?”.* This required them to generate and think about the reasons why they choose to interact with the technology, or ignore it. In order to analyse the qualitative responses, they were classified into themes inductively, based on the reason(s) given for interacting/ignoring technology. Some cases could arguably have fallen within more than one theme, and in these cases an assessment was made as to the primary motivation. The responses were split into those where interactions had occurred and where they had not, in order to discriminate the reason for and for not engaging with technology while driving. Themes arose from the inductive aggregation of similar reasons. The identified themes were given to a volunteer, who was asked to determine which of the cases fell within each theme. The level of agreement was 83%, which is above the generally accepted level of reliability (Jentsch & Bowers, 2005). The themes and the frequency of reference to each is shown in Table 6.

Table 6. Classification of interaction themes.

|  |  |  |
| --- | --- | --- |
| **Interaction** | **Initiation** | **Reason** |
| Interacted (211) | Driver (178) | Music (103) |
| Navigation (33) |
| Phone (32) |
| Text (5) |
| Camera (3) |
| n/a (2) |
| Notification | Phone (18) |
| Text (10) |
| Nav (4) |
| Passenger interacted (1) |
| Did not interact (163) | No notification (119) | No notifications (36) |
| Could not reach (13) |
| Spoke to passenger (8) |
| No technology in vehicle (6) |
| Journey nearly finished (3) |
| Passenger interacted (3) |
| Music (2) |
| Safety (1) |
| Reports of no technology used during drive (47) |
| Ignored notification (44) | Illegal (13) |
| Journey nearly finished (10) |
| Could not reach (9) |
| Safety (6) |
| Passenger interacted (2) |
| Spoke to passenger (1) |
| n/a (3) |

# Discussion

While there has been much focus on the assessment of distraction in relation to external variables and task capability, the conditions surrounding the uptake of distracting technologies in the real world has been under-researched. A diary study aimed to explore the possibility of collecting information surrounding the drivers’ decision to engage with distractions. This study comprised of fifteen drivers completing a diarised record of their interactions with technologies while driving, under naturalistic driving conditions in their everyday lives. This revealed the cases where interactions were motivated by the driver, or where they were a response to the device initiating the interaction. It also captured device interactions that were ignored by the driver. The external factors surrounding why these interactions were sought, to better understand the conditions surrounding distraction engagement.

It was found that drivers interacted with technologies in 56% of the journeys that were recorded across the diary study period. The majority of these interactions were with the in-built infotainment system in their vehicles, yet 87% of participants stated that they interacted with their phone while driving at least once within the study period. This is a figure that is higher than previous approximated by Dragutinovic and Twisk in 2005, who stated 60-70% of drivers report using their mobile phone while driving. Furthermore, across all phone use 43% was hand-held use and 57% was hands-free use. This shows that drivers used their phones illegally in just under half of all the occasions that it was used while driving. Other naturalistic distraction studies have also found concerning levels of hand-held phone use. The Udrive study found drivers engaged in hand-held use of the phone 39% of the time that a phone was used (Carsten et al, 2017) and the Australian Naturalistic study stated that hand-held phone use was as high as 82% of all phone use (Young et al, 2019). There was, however, some evidence in the Australian study to suggest that mobile phone conversations were shorter to limit their risk when using the phone without hands-free (Young et al, 2019). These findings support previous evidence to suggest that current laws on driver distraction are not doing enough to encourage safe use of mobile phones while driving (Parnell et al, 2017). In-vehicle infotainment systems were accountable for the majority of interaction with 108 interactions recorded (51% of the total), all of which were driver initiated rather than device initiated. In fact, 84.83% of the interactions were initiated by the driver, with the others being initiated by the device via notifications and/or alerts. Yet, nearly a third of these notifications were ignored by the driver to prevent the interaction from occurring. This could suggest that drivers are becoming less sensitive to distractions which have previously been motivated by social pressure (Walsh et al, 2010) or it could indicate overexposure to technological notifications and an improved ability by users to inhibit them.

## Demographics

The female participants were found to ignore more of the technological interactions than their male counterparts. Further research is required to obtain insights into the validity of this finding as the sample was small (8 males, 7 females), as was the effect size for this result (r=0.16). Previous finding suggest it could be due to males having and increased likelihood of taking risks (Vavrik, 1997; Rhodes & Pivik, 2011) and engaging in more unsafe behaviours more generally (Harré et al, 1996). A review of the reasons that males and females stated they ignored technological distractions identified that males were more concerned on the legality of using devices such as mobile phones while driving (e.g. “*Didn't want to risk points on licence*” (P5). Whereas, the main reason that females gave was in relation to ignoring phone interactions due to the phone being out of reach, in bag on the passenger seat, back of the car or in their pocket so that they couldn’t reach it. This raises interesting questions on the location and placement of devices in vehicles across genders.

## External Factors

The diary entries required participants to enter information about the context surrounding the interactions that they recorded, including the road type, weather conditions, presence of passengers, traffic, journey length and purpose of their trip. These are factors that have been linked with driver distraction (e.g. Ranney et al, 2000), but whose naturalistic effects cannot be easily replicated within driving simulator studies, where drivers are aware their behaviour is under assessment. The advantage of the diary was its ability to capture the behaviour within its naturalistic setting where the risks of engagement and motivations to engage are from the real world.

Previous research using driving simulator research has evidenced the adverse effects of increased demand in the driving task that increased the degradation of safe driving behaviour in the presence of distractions (see Young & Regan, 2007 for a review). The complexity of the road environment has been negatively related to the drivers’ ability to monitor and track the driving environment when engaging with both hand-held and hands-free mobile phone tasks (Strayer & Johnson, 2001). Lead breaking time has also been found to increase with hands-free phone conversations in complex road environments (Strayer et al, 2003). Adverse weather conditions have been found to negatively impact on the drivers’ ability to safely engage with mobile phone-based distraction (Cooper & Zheng, 2002).

Simulator based research highlights the adverse effects of distractive behaviour in unfavourable driving conditions, yet it does not determine how the drivers’ decision to engage may be affected by these conditions, which may in fact limit the opportunity for adverse consequences from occurring (Parnell et al, 2018c). Interview research that targeted drivers’ intention to engage has found that drivers report to be differentially likely to engage with distracting technologies depending on the type of road they are driving on e.g. Motorway versus residential road, as well as the type of task that they require e.g. text messaging versus changing a song (Parnell et al, 2018a). The reasons for their engagement, or lack thereof, were related to the road infrastructure, the task, the context as well as the drivers own beliefs (Parnell et al, 2018a).

Contrary to this, the findings from this diary study found no significant effect of any of the external environmental factors that were included in the diary questionnaire, as shown in Table 3. This could suggest that factors such as the weather, presence of passengers, road type or the purpose of the trip do not have any bearing on the drivers’ decision to engage with technological devices in the real world. Yet, with a larger sample size this would become more evident. Running a diary study over a period of year would incorporate a more representative record of weather conditions. Furthermore, route familiarity may play a role as many of the drives that drivers perform on a day to day basis are familiar to them e.g. commuting to work, going to the shops or visiting friends. Distraction has been found to be more of an issue on familiar routes with more frequent interactions and more erratic driving performance (Wu & Xu, 2018). This may have lessened the effect of other environmental factors.

## Activity Type

The most common individual type of activity that drivers engaged with was a physical interaction, although multiple combined activities were the most frequent where the technology required them to monitor, interact and read. For example, when following instructions from a navigation device. The interactions that require the driver to perform multiple activities will place more load on the drivers’ attentional resource according the Multiple Resource Theory (MRT; Wickens, 2002), especially when the resources required by the secondary task are also required for safe engagement in the primary driving task. Activities such as monitoring and reading will therefore be competing with the driving task for visual resources, taking the drivers eyes away from the road. The tasks that were reviewed do, however, involve different degrees of visual attention. Targeted glances to the infotainment system, for example, are less visually intensive tasks than more involved task such as such as texting (Caird et al, 2014).

While no evidence for external factors was found, this study did, however, support previous findings that the task type influences the drivers’ interaction with the device (Parnell et al, 2018a). Firstly, the frequency of interactions being device initiated rather than driver initiated varied depending on the type of activity that the device required. Specifically, tasks that required drivers to engage in a reading activity with the device occurred significantly more than expected, while driver initiated reading tasks occurred far less than expected. This suggests that while drivers themselves do not readily volunteer themselves to engage with reading tasks while driving, when devices notify them to engage with them and perform a reading task they will be more likely to do so. This was also true for speech-based tasks, with drivers engaging in speaking tasks with the device significantly more than expected. This is an interesting finding as both speaking and reading tasks that were device initiated predominantly related to mobile phone tasks e.g. answering a phone call and reading a text. This included both hand-held and hands-free phones. Thus, phone devices may be initiating activities that require the driver to read or speak more than they would usually decide to initiate by themselves.

Looking further into the comments that the drivers stated when they interacted with reading tasks that were device initiated, it is evident that the majority of events related to text messages that they received and were alerted to that subsequently captured their attention, see Table 7. This finding is similar to reports from driver interviews (Parnell et al, 2018a) and during verbal protocol reports while driving (Parnell et al, 2018b). Here drivers stated they were likely to divert their attention towards a message when they have been alerted by the device and that this is more likely to encourage them to read it than if there was no alert and they chose to pick up the phone themselves. The reported reasons that drivers gave for interacting with device initiated reading tasks in Table 7 highlight this point.

Table 7. Cases where drivers engaged with a task that involved reading and was device initiated. Table includes the reason given and the device type.

|  |  |
| --- | --- |
| **Reason** | **Device** |
| I had message about meeting so checked it was still on and nothing has changed. Didn’t need reply but probably would have replied if I needed to as was important. | Phone |
| Message to do with a family member who is unwell so I read the first part of the message whilst driving | Text |
| To check a text on my phone as it could have been important | Text |
| To check phone as I heard it go off | Phone |
| Beep from text checked to see if it was anything important | Text |
| Had a long journey left and needed to check to see if the text was anything important. It wasn’t. | Text |
| On way home and received text. Was stuck in traffic. | Text |
| Read a text from partner, as I was waiting at the traffic lights | Text |

## Device Type

The majority of interactions related to tasks on the in-car infotainment system and interestingly all of these tasks were driver initiated rather than device initiated. While this is positive as it suggests that the in-car devices are not actively requesting interaction from the driver, it does highlight the high levels of motivation that drivers have to interact. It can be argued that some interactions with infotainment systems are highly over-rehearsed interactions that require very minimal levels of attention to enact, for example changing the volume. This is especially true when assessing interactions with steering wheel controls that often do not require the driver to take their eyes off the road. However, the adverse of interactions with touchscreen infotainment systems have been highlighted in modern automobiles (Srayer et al, 2017). A significant effect of the device type on the interaction type (driver versus device initiated) was found. Yet, when the unanimous number of infotainment-related driver-initiated interactions were controlled for, this was not found to be significant. Despite no clear device type effects there were some interesting findings related to the compensatory behaviours that drivers engaged with across devices.

## Compensatory behaviours

Drivers were asked to note down if they were aware of any active attempt to compensate for their interactions in the driving task when engaging with technological devices. Findings from the literature suggest that drivers slow down (Rakauskas et al, 2004; Cnossen et al, 2004) or increase their distance to a lead vehicle (Alm & Nilsson, 1995) when interacting with distracting tasks such as mobile phones. The questionnaires showed that drivers did engage in these compensation strategies on occasion, as well as stating other compensatory mechanisms such as going into the slow lane. A finding that supports those identified by Parnell et al (2018b) in driving study. A significant effect of interaction type (driver versus device initiated) on whether or not drivers compensated for their behaviour was found. This identified that drivers compensated more than expected when the interaction was device initiated, but less so when they were the ones who chose to initiate the task. This suggests why previous findings using driving simulators found evidence for compensatory mechanisms (Alm & Nilsson, 1995; Strayer et al, 2003), as interactions were prescribed rather than chosen by the driver. Yet, it does also suggest that drivers may be more selective about when they choose to interact with distracting technology, which could have reduced their need to make active compensatory strategies within the driving task.

Furthermore, a significant main effect of device type was found on the presence or absence of compensation mechanisms. Drivers compensated less than expected when engaging with in-vehicle information systems. This may be due to the fact that all interactions were driver initiated and therefore were less likely to need compensation as discussed above. Furthermore, the compensations are likely to be pre-planned in anticipation of performing the task, while the tasks that were not driver initiated may not have provided little opportunity nor resources for planned compensatory mechanisms. Alternatively, it may also link to the previously identified belief by drivers that devices built into the vehicle are safe to use while driving and do not impact on driving performance (Parnell et al, 208a) and therefore do not need to be compensated for. Indeed, some simple interaction tasks within the infotainment system, such as volume control, provide minimal distraction. Interactions with hand-held mobile phones were actively compensated for more than expected, which aligns with previous findings in driving simulator research (Alm & Nilsson, 1995; Strayer et al, 2003). Yet, it also acknowledges that drivers are aware of these compensatory mechanisms and self-report them within such a study as this.

## Methodology

This was the first attempt at applying a diary study methodology to the study of driver distraction. Its use allows an understanding for the context surrounding the initiation of distracting tasks in the vehicle which are just as important to consider in understanding the problem as the adverse consequences that distractions have on driving performance (Parnell et al, 2018c). When studying driver distraction, it is important to understand the wider and context and systemic influences with which is arises, not just the negative consequences it can have on driving performance (Young & Salmon, 2015; Parnell et al, 2018d). It is only through determining the true causes and emergent factors that predispose the ineffective and unsafe interactions with distractions, that effective countermeasures to the issue can be fully realised (Young & Salmon, 2015; Parnell et al, 2018d). The use of the diary entries allowed for a broad range of factors to be reported by the driver while they performed their everyday driving behaviours over a 4week period. It also enabled an opportunity to capture the interactions with technology that was intentionally ignored by drivers, an aspect of the behaviour which is difficult to determine in simulator and observation studies. The diary study therefore generated a rich data set from a relatively small sample of drivers. It could also be set up and conducted with relative ease and limited costs, in contrast to driving simulator and naturalistic driving studies,

### Limitations and further work

There are some limitations with the study that the readers should be aware of. Primarily, the study recruited a small participants sample which may limit the generalisations that can be made. Each participant did record the required number of questionnaires, yet a variety of individual differences could not be controlled for. An effort was made to recruit a comparable number of females and males, yet a specified age range was not set. The increased likelihood to engage with risky behaviours that has been linked to younger drivers (Rhodes & Pivik, 2011) was therefore not accounted for. Neither was the potential for older drivers to engage less with technologies (Parnell et al, 2018a). No effect of passengers was found. Only a third of journeys recorded actually involved passengers. This is in keeping with UK statistics that state single occupancy trips comprise approximately 62% of all trips (Statistica, 2018). Other research suggests passengers can reduce the number of distractions by performing the task themselves (McDonald et al, 2016). Unfortunately, this study was unable to capture how many distractions could have been avoided due to passenger interaction. The age of the passengers and different passenger characteristics was also not captured, which have been cited as an important factors (Masselo et al, 2019; Koppel et al, 2011). Only a single smart watch interaction was identified, and only two participants stated that they wore a smart watch. This work was conducted in 2017 and it is predicted that wearable technology prevalence has increased since then and will continue to do so in the future (Strain et al, 2019). Thus, further work should seek to upscale the diary study to further explore the influence of external factors and task related features that influence the drivers’ decision to engage with distracting technologies while driving. It would also be useful to capture more details on the context of journeys where no interactions with technologies occurred in order for a comparison to be drawn between this and journeys where interactions were made. Another limitation is that, as with other self-report methods, the data is dependent on the truth and openness of the participant as well as their reliability in recording the information correctly and wholly. Although it was communicated to participants that there would not be any repercussions to reporting potentially illegal activity, it is likely that social desirability bias would have affected reporting. This is, however, a factor that is central to capturing driver distraction across simulator and naturalistic driving studies where participants are aware they are being studied. There may have also been a recollection bias as there were multiple factors that the participants were asked to report and the accuracy with which they were able to recall them may have been limited by their memory for the specifics of all interactions. There may have also been missed interactions that were not recorded, despite best efforts to make the diary visible and provide training to keep the diary updated. An alternative approach could have utilised an app-based diary that could log the GPS, sound, activity, movement in the car or of a device which could then be used to log possible interactions and cue the driver to enter the corresponding diary entry for the interaction. This would assist with the recollection of the activity, when it occurred and its duration. Features such as this should be explored in future diary study research to limit the biases reported here.

After conducted this diary study, it would have been interesting to observe how the documenting of interactions while driving may have changed the participants views on their driving behaviours and led to any intended behaviour change. The active participation in the diary documentation of this method allows participants to become aware of their behaviour in their everyday lives, more so than other methods of study and therefore could be explored as a method for behavioural change. This is something that should be followed up in future work.

# Conclusion

This paper has shown the viability of conducting a diary study to capture drivers’ interactions with distracting devices, the factors that impact on this and the reasons why. Research exploring the effects of external factors on the drivers’ ability to become distracted have utilised controlled environments such as driving simulators as well as naturalistic observation studies. Yet, this study required drivers to retrospectively state any technological devices as well as capture factors that surrounded this and the reasons why it occurred. While also capturing the real-world conditions and intentions. In contrast to simulator studies that identified external factors contributing to distraction events, this study found limited evidence for factors such as the weather, road environment, or the presence of other passengers influencing the drivers’ interaction with distracting technologies. Yet, it supports others in highlighting the relevance of the task itself and the activity that it encourages. This also was found to influence the compensatory strategies that drivers reported to engage with. It was found that drivers report to compensate more when interacting with device initiated tasks than tasks that they initiate themselves. This provides interesting questions on the generalisation of findings from simulator studies that show compensatory behaviours from controlled device initiated tasks. It also suggests that drivers do some pre-planning of their intended interactions so that compensation mechanisms are not required.

The diary study method offers some promise in understanding the intention to engage with distracting technologies and the wider context within which it occurs. This is important as distraction related research has been less focused on the reasons behind why drivers engage with distractions, even though this is an important question that offers the potential to inform useful recommendations. Caution should however be applied as several opportunities for biases in the reporting of behaviours using this method have been identified. In contrast to large scale longitudinal studies, where interactions are captured independent of the drivers, this method required drivers to self-report their interactions and may therefore not be as accurate. Methods for working around this should be the focus of future work.

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